# The Journal of Bone and Joint Surgery

*The Official Publication of*
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
The Australian Orthopaedic Association
The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
South African Orthopaedic Association

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*American Volume*

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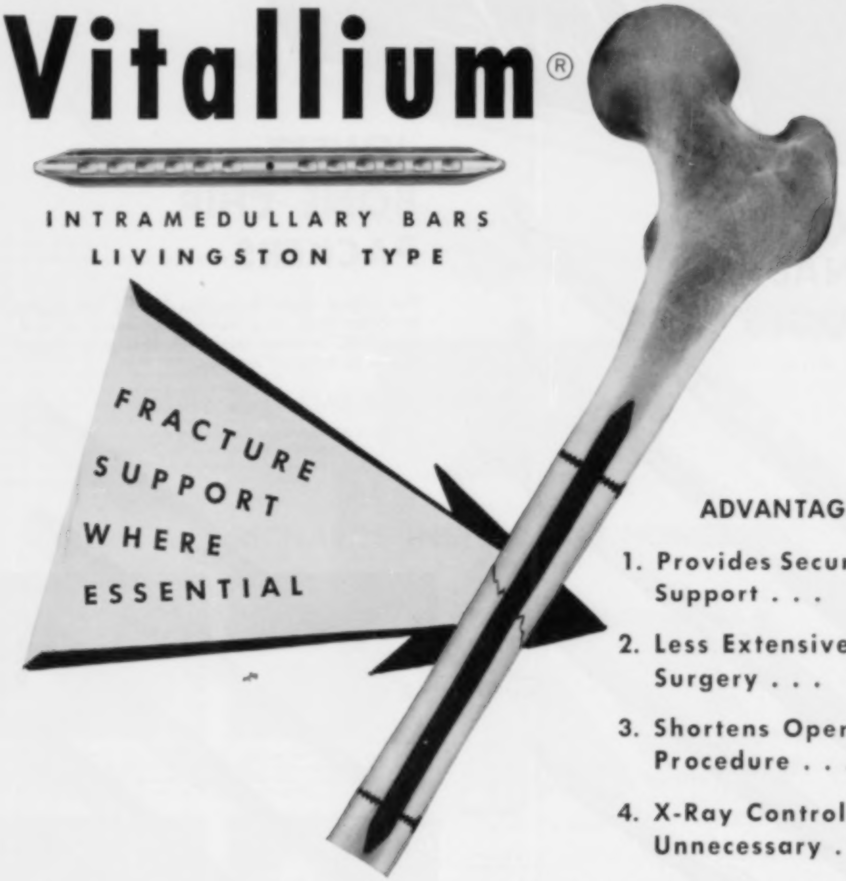

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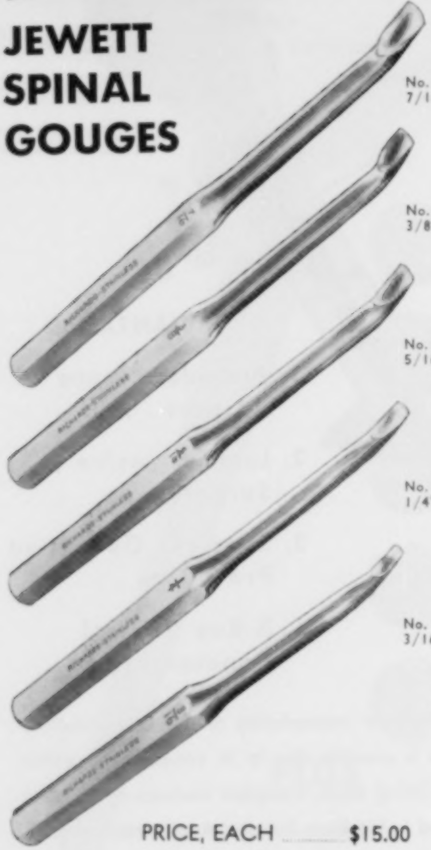

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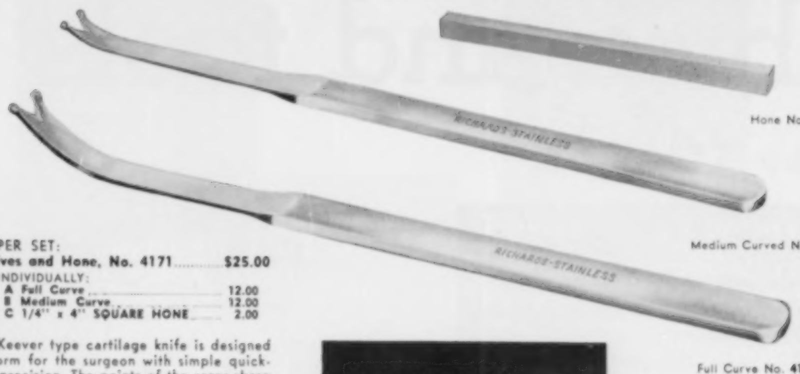

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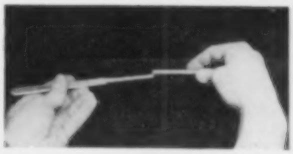

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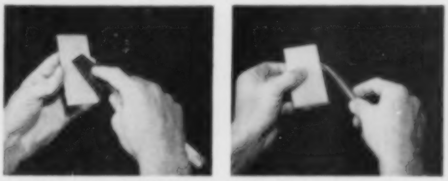

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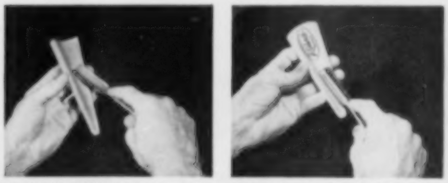

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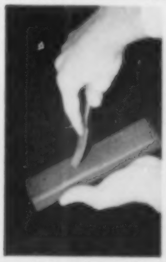

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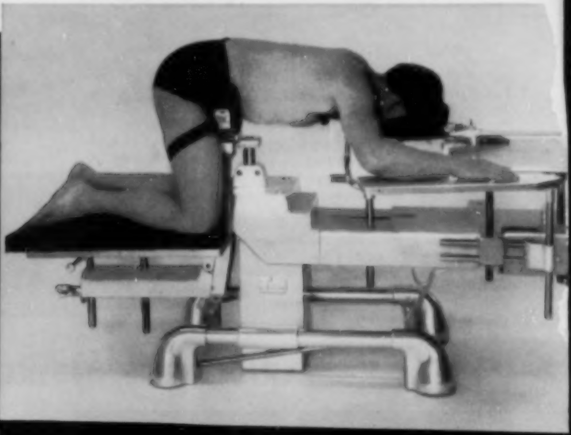

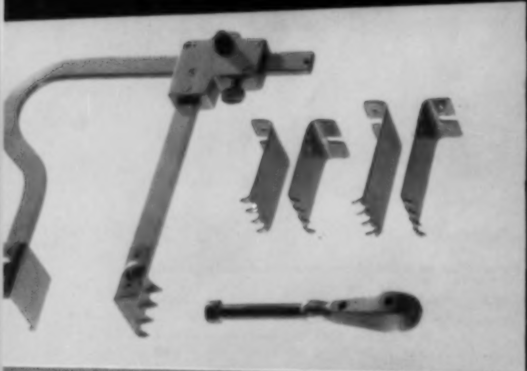

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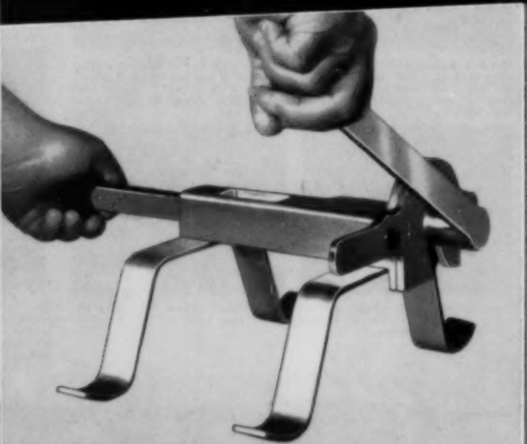

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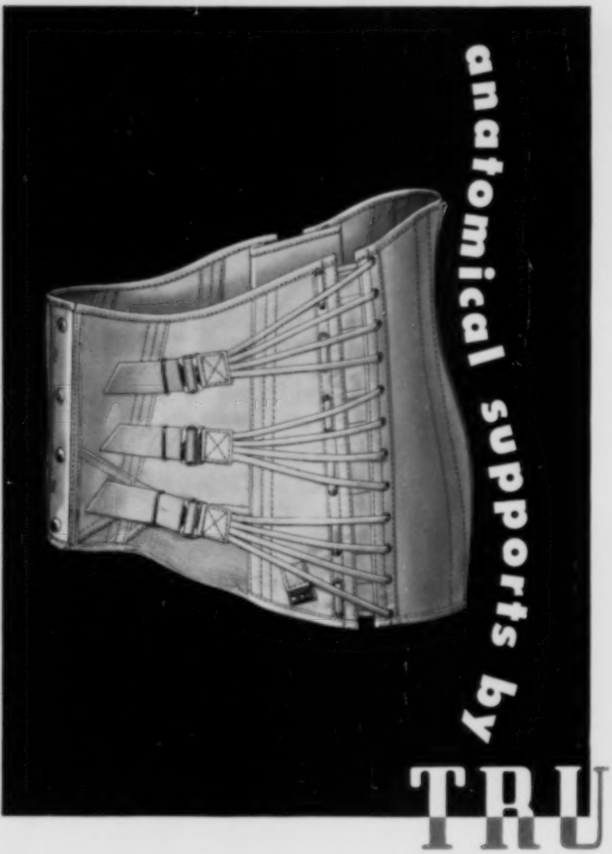

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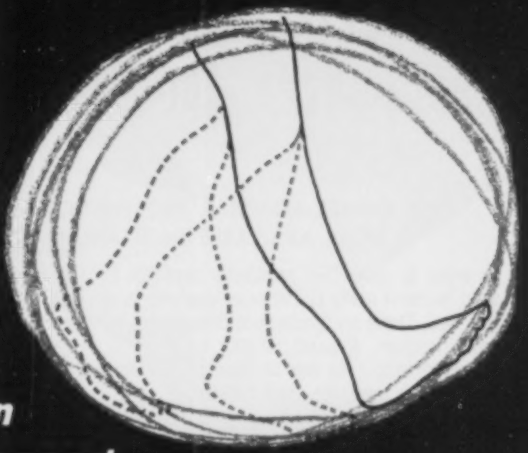

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*rapidly increased*

# in Rheumatoid Arthritis

# Sterane*

***the most potent anti-arthritic***

3 to 5 times more potent than hydrocortisone or cortisone

notably free of major hormonal side effects such as edema due to sodium and water retention, hypopotassemia, and hypertension

seldom requires low-sodium diets or potassium supplements in patients without cardiac complications when given in usual therapeutic dosage

preliminary findings,[1] based on the measuring of pituitary ACTH suppression potency of various corticoids, appear to indicate that STERANE is 20% more potent than the cortisone analog, prednisone

supplied: in white, scored 5 mg. tablets in the familiar Pfizer oval shape. Bottles of 20 and 100.

[1] Forsham, P. H., et al.: Paper presented at First Internat. Conf. on Prednisone and Prednisolone, New York, N. Y., May 31-June 1, 1955.

*brand of prednisolone

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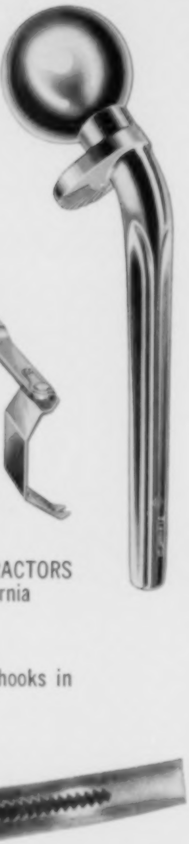
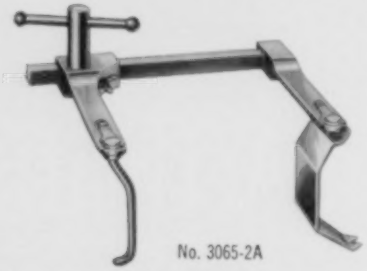
# Zimmer Instruments and Appliances for Orthopedic Surgery

## THE EICHER FEMORAL PROSTHETIC HEAD NOW AVAILABLE IN TITANIUM

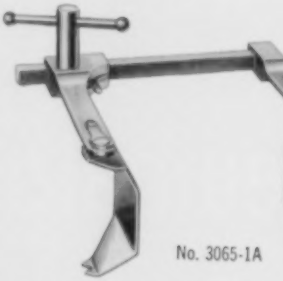


In order to make this prosthesis available for those doctors who want to use it made of Titanium, we have in stock the various sizes as listed. These are made from drop forged one-piece commercially pure Titanium. A paper written by Floyd H. Jergensen, M.D., of San Francisco, "The Use of Titanium Prosthetically in Orthopaedic Surgery," is available upon request.

No. 4530—Head sizes available—41, 43, 45 and 47 MM



No. 3065-2A



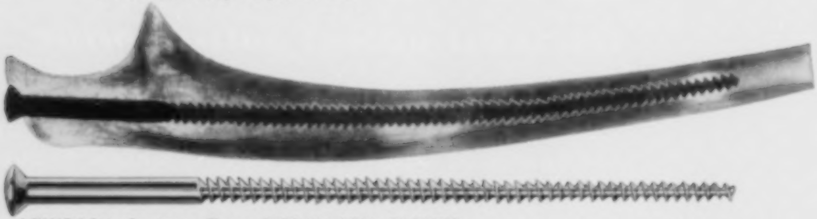
No. 3065-1A

## DOWNING LAMINECTOMY AND HEMILAMINECTOMY RETRACTORS

as designed by F. Harold Downing, M.D., Fresno, California

No. 3065-1A Downing Laminectomy Retractor @ $62.00
No. 3065-2A Downing Hemilaminectomy Retractor @ $61.00

The frame of this retractor is universal so that blades or hooks in three sizes may be purchased.



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For Fixation of Fractures of the Olecranon Process
SMo Stainless Steel

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1. Fiskio, P. W.: To be published; 1a. Personal communication.

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ideal preparation for combined estrogen-androgen therapy

Supplied in two potencies: *Yellow* tablets (No. 879) contain 1.25 mg. of conjugated estrogens (equine) and 10 mg. of methyltestosterone; *red* tablets (No. 878) contain 0.625 mg. and 5 mg. respectively. Available in bottles of 100 and 1,000.

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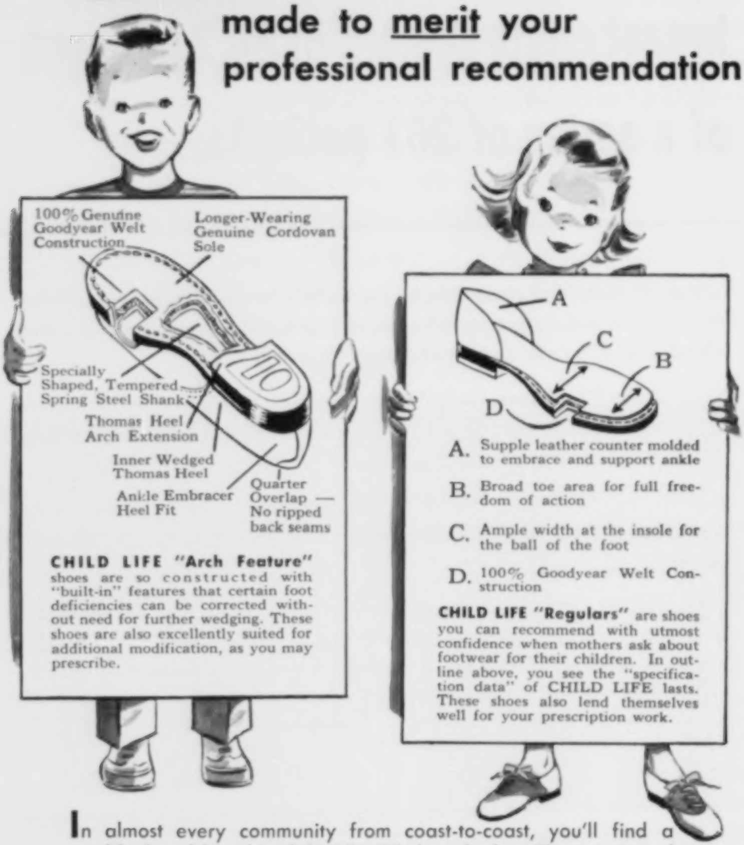
made to merit your
professional recommendation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Thomas Heel Arch Extension
Inner Wedged Thomas Heel
Ankle Embracer Heel Fit
Quarter Overlap — No ripped back seams
A
C
B
D

**CHILD LIFE "Arch Feature"** shoes are so constructed with "built-in" features that certain foot deficiencies can be corrected without need for further wedging. These shoes are also excellently suited for additional modification, as you may prescribe.

A. Supple leather counter molded to embrace and support **ankle**

B. Broad toe area for full freedom of action

C. Ample width at the insole for the ball of the foot

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**CHILD LIFE "Regulars"** are shoes you can recommend with utmost confidence when mothers ask about footwear for their children. In outline above, you see the "specification data" of CHILD LIFE lasts. These shoes also lend themselves well for your prescription work.

In almost every community from coast-to-coast, you'll find a qualified and franchised CHILD LIFE shoe dealer. These men and women have been selected for their knowledge of good fitting practices, and for their specific interest in children's footwear. You'll find them most co-operative and attentive to your prescription work. Please write for full information on CHILD LIFE shoes — on the market since 1924 — and the names of the CHILD LIFE dealers nearest you.

**HERBST Shoe Manufacturing Company**
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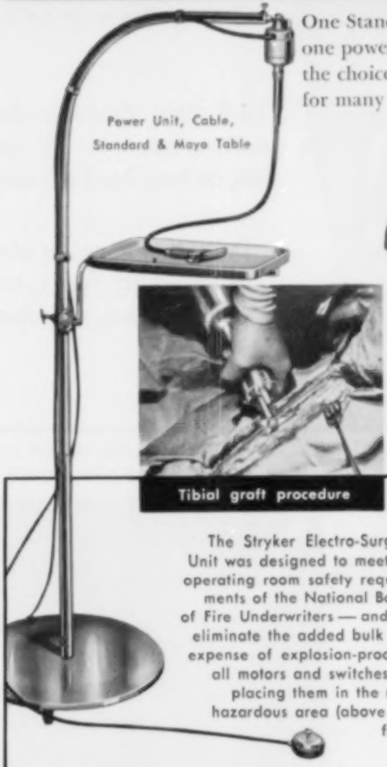
**One of a Series — The Stryker Bone Saw Attachment**

One Standard and Mayo Table with one power unit gives the surgeon the choice of six powered instruments for many surgical specialties.


Power Unit, Cable, Standard & Mayo Table
Tibial graft procedure

Only high speed oscillation makes possible the use of a variety of blades to make every cut the surgeon desires efficiently and without danger to the soft tissues.

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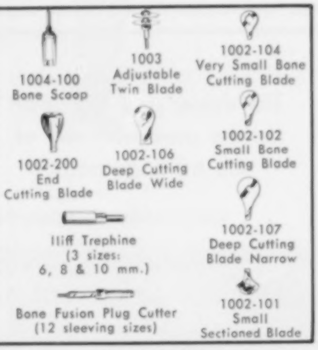
1004-100 Bone Scoop
1003 Adjustable Twin Blade
1002-104 Very Small Bone Cutting Blade
1002-200 End Cutting Blade
1002-106 Deep Cutting Blade Wide
1002-102 Small Bone Cutting Blade
Iliff Trephine (3 sizes: 6, 8 & 10 mm.)
1002-107 Deep Cutting Blade Narrow
Bone Fusion Plug Cutter (12 sleeving sizes)
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Rotary Burring Handpiece
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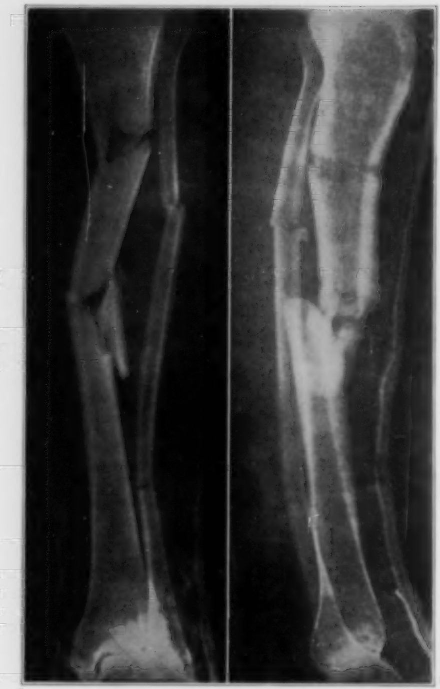
Winnipeg, Manitoba

Orthopedic FRAME COMPANY
Kalamazoo Michigan



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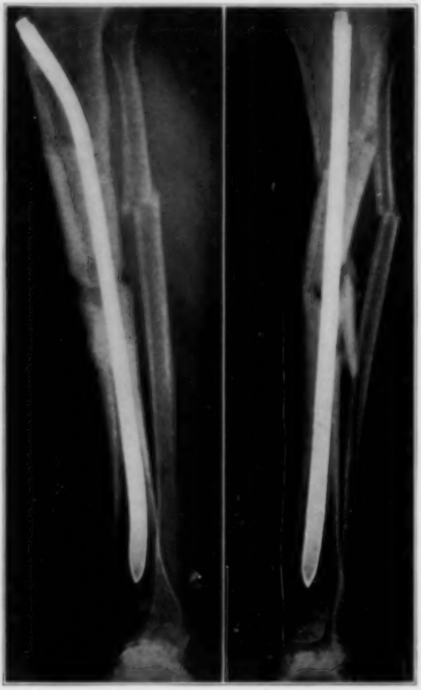
LOTTES TRIFLANGE TIBIAL NAIL
Tibial Nail diameters: 5/16" and 3/8"

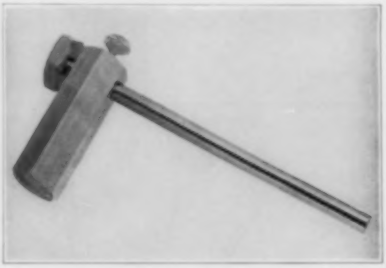
18-8 SMo Stainless Steel nail made in ½ inch lengths from 9 to 14½ inches.

The triflange nail is also available for femur, humerus, radius, and ulna.

COMPOUND FRACTURE WHICH WAS DEBRIDED, CLOSED, AND PLACED IN CAST ON ADMISSION ● RESULT THREE MONTHS AFTER PRIMARY HEALING OF WOUND AND CLOSED NAILING



The driver and extractor can be used with any of the triflange nails.



DRIVER AND EXTRACTOR

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Pabirin is a **DORSEY** preparation.

Each capsule contains:

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| Acetylsalicylic acid | 5 gr. |
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Supplied: In bottles of 100, 500 and 1,000 capsules.

**Pabirin®**

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*Based on the most modern research program*

- Long inside counter
- Heavy gauge ribbed steel shank
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- Patented bottom filler prevents insole lumping

*Alden-Pedic lasts are designed to accommodate your prescribed corrections and insertions. Extreme sizes stocked. Many styles available for men, boys. Top quality only.*

Alden-Pedic lasts and shoes have been scientifically designed and tested to accommodate specific and general degrees of foot disabilities. To fit the foot shape and accommodate the prescribed corrections is the crux of our program. Doctors who become familiar with the functional merit of this program will be glad to prescribe these shoes as a foundation in the treatment and correction of foot disabilities. We do not claim that these shoes will correct abnormal foot conditions, but they will provide the types of basic footwear necessary as a foundation in aiding foot trouble and in offering foot comfort. We know you will be glad to recommend them.

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THORAZINE*

**calms** the apprehensive and anxious patient
**facilitates** induction and intubation
**potentiates** analgesics and anesthetics
**controls** nausea, vomiting, hiccups and emergence excitement

"A measure of protection from shock is suggested in a number of cases."—Lear, Chiron and Pallin[1]

'Thorazine' Hydrochloride is available in ampuls, tablets and syrup.

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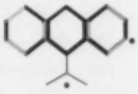
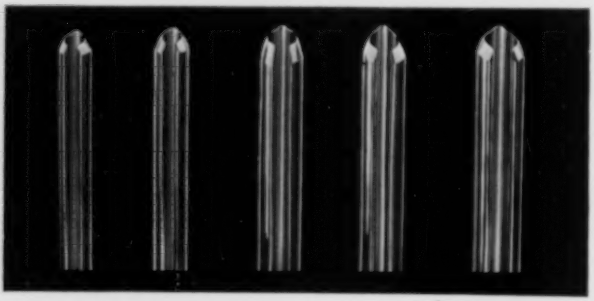
1. Lear, E.; Chiron, A.E., and Pallin, A.M.: Chlorpromazine—An Adjunct to Premedication, Clinical Report Based on 1,100 Cases, New York State J. Med. *55*:1853 (July 1) 1955.

*T.M. Reg. U.S. Pat. Off. for S.K.F.'s brand of chlorpromazine.



# *Original* Küntscher Cloverleaf Medullary Nails *by Orthopedic*



*Look at these outstanding advantages:*

- Built according to original Küntscher design.
- Nails are formed by drawing so there is no possibility of fracturing metal.
- Made from SMo stainless steel.
- Nails have large slot—can be extracted with practically any type extractor.
- Greater strength resulting from true roundness of trefoil.
- Has rounded cusp; no sharp bends or angle points where metal can fracture.

**No. 401-1**—*Küntscher Cloverleaf Type Medullary Nail, 12mm width, specify lengths of 36, 38, 40, 42, 44, 46, 48, 50, 52 cm.*
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**No. 402**—*10 mm x 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52 cm.*
**No. 403**—*9 mm x 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52 cm.*
**No. 404**—*8 mm x 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52 cm.*
**No. 405**—*6 mm x 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42 cm.*

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OEC *Orthopedic* EQUIPMENT CO.
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SPLINTS • FRACTURE EQUIPMENT • SMo INTERNAL BONE APPLIANCES • BONE INSTRUMENTS

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4" WIDE
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**FAST-SETTING**

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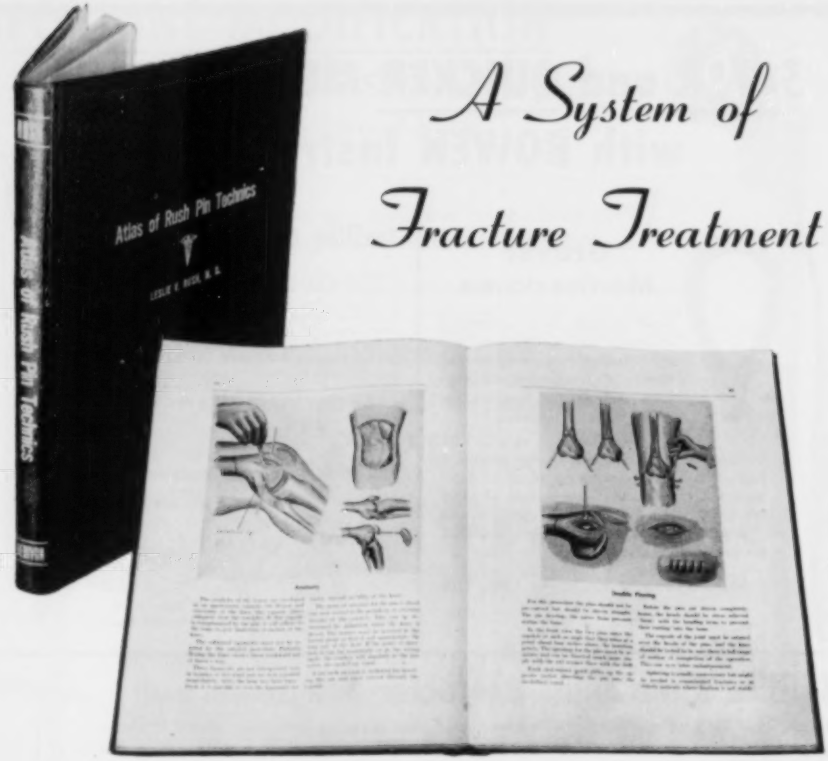
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LESLIE V. RUSH, M.D.
ATLAS OF RUSH PIN TECHNICS

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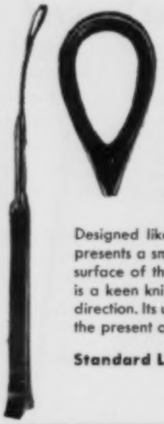

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Used through any arthrotomy exposure and on either semilunar cartilage, it guarantees the integrity of all structures within the joint and permits complete removal of either meniscus.

Designed like a large intra-uterine curette, it presents a smooth rounded guard on the outer surface of the ring, the inner margin of which is a keen knife edge permitting cutting in any direction. Its use will shorten by about one-third the present operating time.

**Standard Length: 8½" • No. 128**

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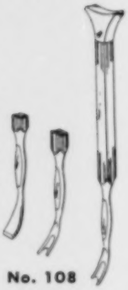
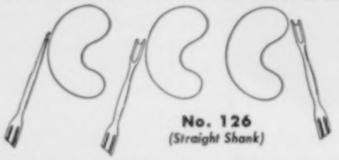


**No. 108**

*(Curved Shank)*

ILLUSTRATIONS SHOW POSITIONS OF KNIVES IN USE



**No. 126**

*(Straight Shank)*

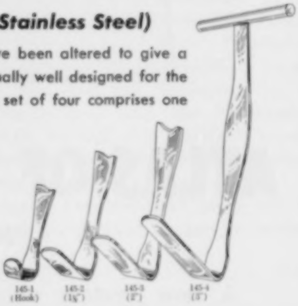
## Smillie Knee Joint Retractor Set *(Stainless Steel)*

The angles of the blades and the modified handles of these retractors have been altered to give a better grip and keep the fingers away from the incision. They are exceptionally well designed for the removal of menisci and for use in practically all knee joint operations. The set of four comprises one hook and three with blade lengths from 1½ inches to 3 inches.

**FEATURES:** "Sure grip handles for perfect control." • "Hardened and tempered to rigid specifications." • "Useful retractors for many other surgical procedures."

**No. 145 Knee Joint Retractor Set—$30.00**
(Four Pieces)

Priced Individually at $8.00 each



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*Unique!*

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**For the dispensing of alcohol and other cleansing liquids.**

Patent Applied For

- *Quick Acting* • *Unbreakable* • *Will Not Tip*
- *Easily Operated with one hand*
- *To Use, Just Press on Metal Plate!*

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**$1.50**

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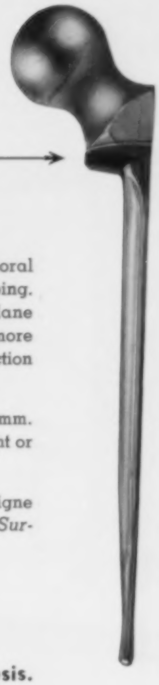

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**TECHNIQUE:** Refer to paper by R. Merle d'Aubigne and M. Postel, *The Journal of Bone and Joint Surgery,* 36-A, No. 3, 451–475, June 1954.

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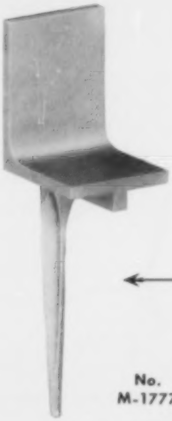

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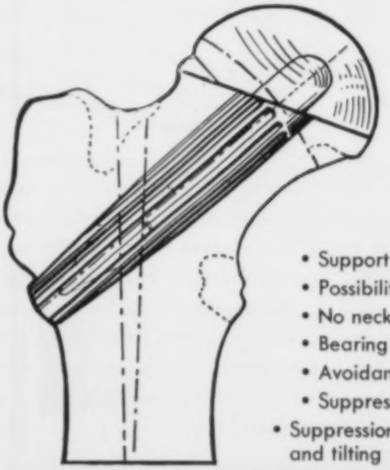

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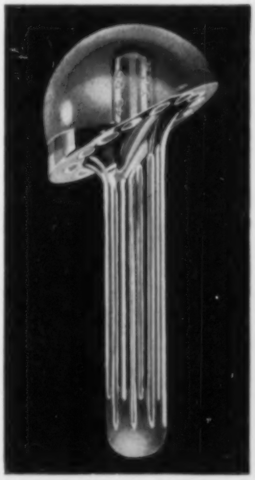

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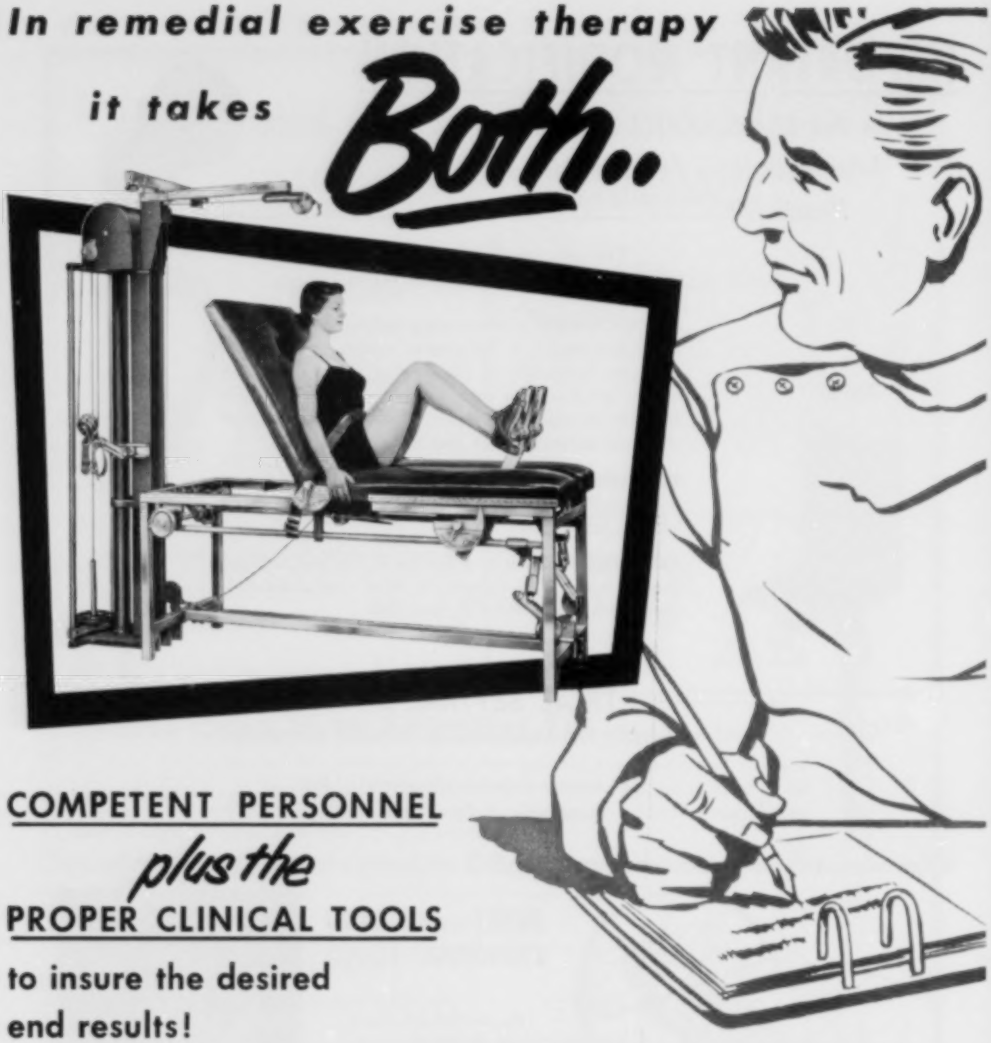

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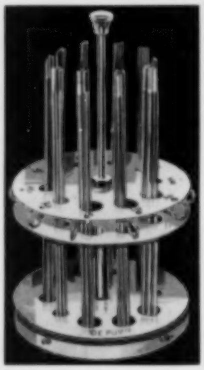

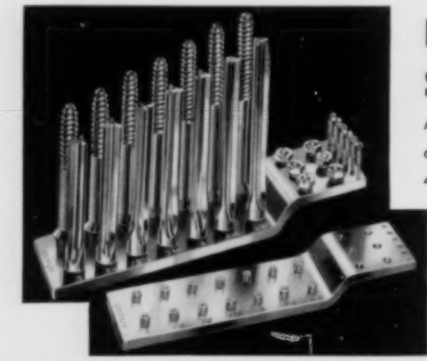

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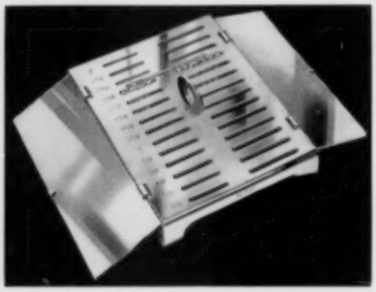

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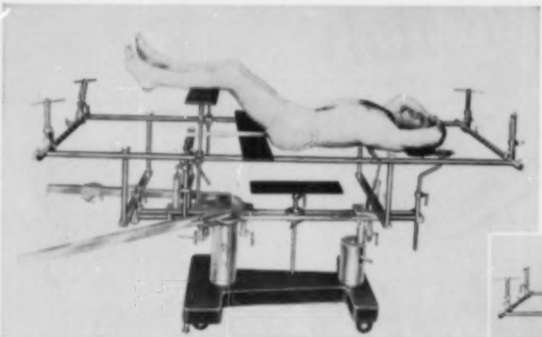
For DV and BELL Tables



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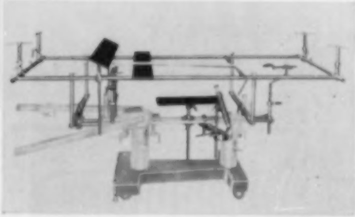
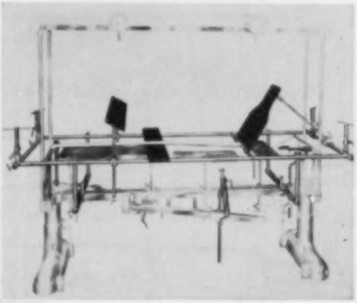
Attachment used on the DV Table showing patient in position for Anti-gravity Cast.

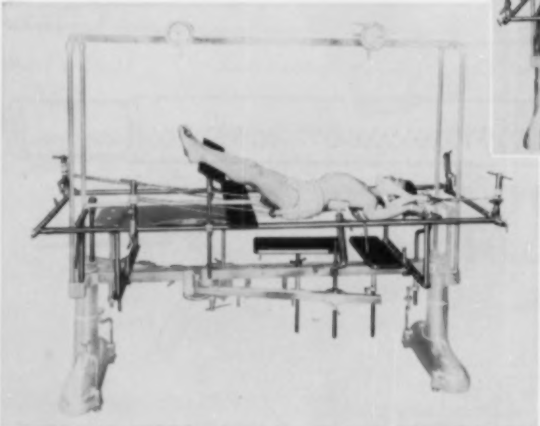


Risser Scoliosis Attachment on DV Table



Risser Scoliosis Attachment on Bell Table

Attachment on Bell Table showing patient in position for Localizer Cast. Notice Independent traction units—also notice Bell traction piece converted to "pusher" for localized pressure.



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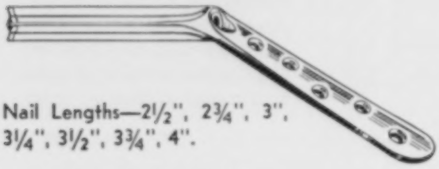

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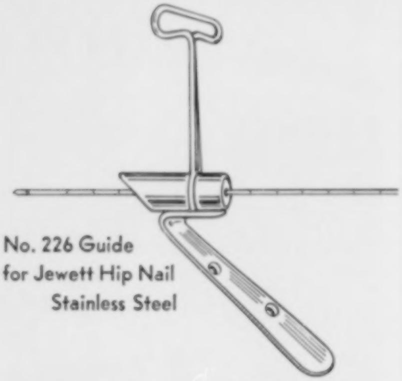
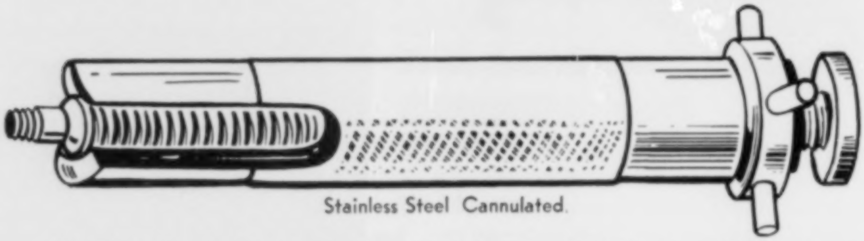
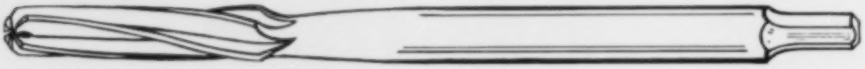


No. 226 Guide for Jewett Hip Nail Stainless Steel

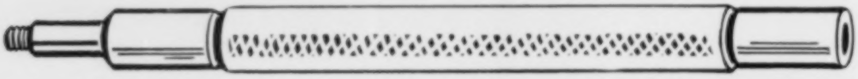


Stainless Steel Cannulated.

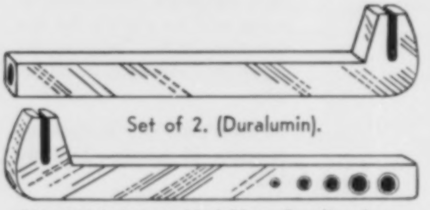
No. 208J Extractor-Impactor for Jewett One Piece and Smith Petersen Hip Nails.



No. W402J Henderson Cortex Reamer. Cannulated. Fits Jacobs Chuck. Stainless Steel.



No. 225 One-Piece Nail Driver. For Jewett Nails. Stainless Steel. Cannulated.



Set of 2. (Duralumin).

No. 219J Jewett Nail Plate Bending Irons.

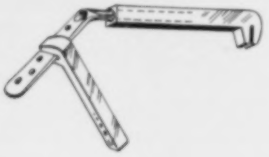


*Illustration shows one of many uses of plate bending irons.*

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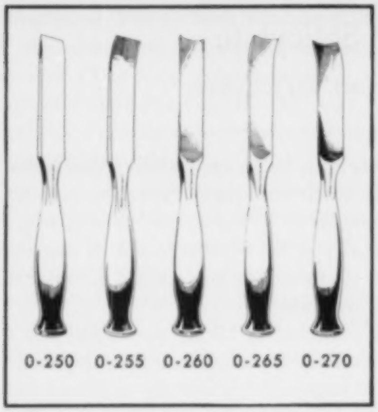

**0-250** SMITH-PETERSEN OSTEOTOME—straight, 8", sizes ¼", ⅜", ½", ⅝", ¾", 1" and 1¼". Stainless Steel.

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**0-260** SMITH-PETERSEN GOUGE—straight, 8", sizes ⅜", 9/16", ¾" and 1". Stainless Steel.

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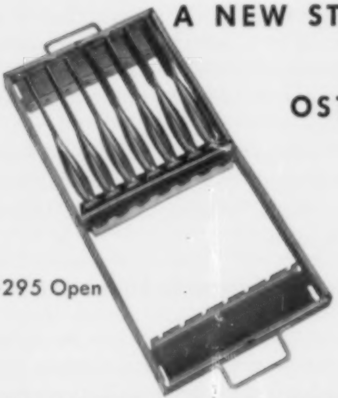
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0-295 Closed

**CASE 0-295**—holds seven Smith-Petersen Osteotomes.

**CASE 0-296**—holds seven Smith-Petersen Gouges.

**CASE 0-297**—holds a combination of seven Osteotomes and Gouges.

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# A Laboratory and Clinical Report on Adrenosem® Salicylate

(BRAND OF CARBAZOCHROME SALICYLATE)

## History

The first investigation of a hemostat with an action comparable to Adrenosem Salicylate was made by Derouaux and Roskam[1] in 1937. They reported that an oxidation product of adrenalin, adrenochrome (which has no sympathomimetic properties), has prompt hemostatic activity.

It was further found that various combinations of adrenochrome, notably the oxime and semicarbazone, produced stable solutions. But, these were so slightly soluble that sufficient concentration could not be obtained for practical therapeutic use. By combining these adrenochrome compounds in a sodium salicylate complex a stable, soluble form can be obtained. This complex has been given the generic name, carbazochrome salicylate, and is supplied under the trade name Adrenosem Salicylate.

Roskam, in his study entitled "The Arrest of Bleeding,"[2] enumerates "the drugs whose efficaciousness as hemostatics have been proved by accurate methods in experimental animals and in healthy men as well. . . . One is the monosemicarbazone of adrenochrome [Adrenosem Salicylate]."

## Chemistry

Adrenosem Salicylate is a synthetic chemical. The full chemical name is adrenochrome monosemicarbazone sodium salicylate complex.

## Pharmacology

Although it is chemically related to epinephrine, Adrenosem Salicylate has no sympathomimetic effects. It does not alter blood components, nor does it affect blood pressure or cardiac rate.[2-7]

Sherber, in an early study,[3] concludes that Adrenosem Salicylate* "is a potent antihemorrhagic factor in those conditions in which the integrity of the smaller vessels is interrupted, and is superior to any similar material that is now available."

He continues, "From our experience it appears that adrenochromazone complex is indicated in preventing vascular accidents incident to hypertension; in maintaining small vessel integrity; in the preoperative preparation where oozing from a vascular bed is anticipated, as in tonsillectomies, adenoidectomies and prostatectomies; and as an adjunct in the treatment of bleeding from such surgical procedures."

Adrenosem Salicylate may be administered simultaneously (but separately) with any type of anesthetic, anticoagulant, or vitamin K and heparin.

## A Unique Systemic Hemostat

Clinical investigators[2-7] are in agreement that Adrenosem Salicylate controls bleeding and oozing by decreasing capillary permeability and by promoting the retraction of severed capillary ends. It aids in maintaining normal capillary integrity by direct action on the intercellular "cement" in capillary walls. The interesting work of Fulton[8] confirms this. Adrenosem Salicylate, since it is not a vasoconstrictor, has no effect on large severed blood vessels and arterioles.

Adrenosem Salicylate is being used both prophylactically and therapeutically in thousands of hospitals, and in virtually every type of surgical procedure. It has also proved most useful in dental surgery.[7]

Owings reported on the use of Adrenosem Salicylate in controlling postoperative adenoid bleeding in 102 cases.[4] "We have used 2½ mg.

---

(* U.S. Patent 2,581,850)

(½ ampule) intramuscularly, 15 minutes before anesthesia for children and 5 mg. (1 ampule) for adults." In only one patient did bleeding occur. Three others showed red blood from the nose and mouth. These patients "were then given 5 mg. intramuscularly, with prompt and complete control. We have also noticed that bleeding stopped more promptly on the operating table."

This is a 1% incidence of postoperative bleeding using Adrenosem Salicylate preoperatively, compared to an incidence of 10% postoperative bleeding in all cases taken from previous records, without Adrenosem Salicylate medication.

Peele reports on the use of Adrenosem Salicylate in treating 178 patients with 24 different conditions.[5] The drug was first used to control postoperative hemorrhage from the adenoid region. He adds: "The results were so dramatic that since that date [1953] Adrenosem Salicylate has been used postoperatively to reduce bleeding from all otolaryngologic and bronchoesophagolic procedures, to treat postoperative hemorrhage from the tonsil and adenoid regions, and to treat selected cases of epistaxis."

The effectiveness of Adrenosem Salicylate in controlling bleeding and oozing in 330 patients is reviewed by Bacala.[6] "Our experience of the effect of carbazochrome salicylate on 317 surgical indications and 13 obstetricogynecological conditions, has been therapeutically encouraging and successful for the control of capillary bleeding. Foremost among the cases studied were 223 tonsillectomies definitely benefited by this metabolic hemostat, making a diminution of the control incidence of post-tonsillectomy bleeding of 19.8% down to 7%. It has also been found useful in gastro-intestinal bleeding, cataract extraction, epistaxis, incisional seepage, trans-urethral prostatectomy, menometrorrhagias, cervical ooze, antepartum and postpartum bleeding, threatened abortion, and prevention of capillary hemorrhages during hedulin or dicumerol therapy."

## Side Effects

All investigators concur that, at recommended dosage levels, Adrenosem Salicylate is free from toxic effects. No cumulative effects attributable to the drug have been reported.

The only side reaction noted has been a transient stinging sensation in the area of injection when Adrenosem Salicylate is used intramuscularly. As one investigator comments: "The brief discomfort which attends the injection of Adrenosem into the gluteal region has not been a significant problem in children or adults as originally anticipated."[5]

## Indications

Idiopathic purpura, retinal hemorrhage, familial telangiectasia, epistaxis, hemoptysis, hematuria.

Postoperative bleeding associated with:
tonsillectomy, adenoidectomy and
nasopharynx surgery;
prostatic and bladder surgery;
uterine bleeding;
postpartum hemorrhage;
dental surgery;
chest surgery and chronic pulmonary bleeding.

## Dosage

For recommended dosage schedules, please send for detailed literature.

## Supplied

| | |
|---|---|
| Ampuls: | 5 mg., 1 cc. (package of 5). |
| Tablets: | 1 mg. S.C. Orange, bottles of 50. |
| Tablets: | 2.5 mg. S.C. Yellow, bottles of 50. |
| Syrup: | 2.5 mg. per 5 cc. (1 tsp.), 4 ounce bottles. |

## References

1. Roskam, J. and Derouaux, G.: Arch. of Intern. Pharmacodynamie **71**:389 (1945).
2. Roskam, J.: Arrest of Bleeding, Charles C. Thomas, Springfield, Ill. 1954.
3. Sherber, Daniel A.: The Control of Bleeding, Am. J. Surg. **86**:331 (1953).
4. Owings, Capers B.: The Control of Postoperative Bleeding with Adrenosem, Laryngoscope, **55**:21 (Jan., 1955).
5. Peele, J.C.: Adrenosem in the Control of Hemorrhage from the Nose and Throat, A.M.A. Arch. of Otolaryng. **61**:450 (April, 1955).
6. Bacala, J.C.: The Use of the Metabolic Hemostat, Adrenosem Salicylate. To be published.
7. Riddle, A.C. Jr.: Adrenosem Salicylate: A Systemic Hemostat, Oral Surg., Oral Med., Oral Path. **6**:617 (June, 1955).
8. Fulton, M.D., Dept. of Biology, Boston University: Personal Communication.

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Saline Suspension HYDROCORTONE-T. B. A. is particularly advantageous in the treatment of patients with rheumatoid arthritis or osteoarthritis. While severely inflamed joints may require one or more injections a week, the milder cases may show benefit for as long as 8 or 9 weeks.

Since the anti-inflammatory action is entirely local, HYDROCORTONE-T. B. A. may be used in conjunction with systemic steroid therapy as well as in those patients in whom systemic therapy is contraindicated.

**SUPPLIED:** Saline Suspension HYDROCORTONE-T. B. A.: 25 mg./cc., vials of 5 cc.; Saline Suspension HYDROCORTONE Acetate: 25 mg./cc., vials of 5 cc. ORAL—HYDROCORTONE Tablets: 20 mg., bottles of 25, 100, and 500 tablets; 10 mg., bottles of 50, 100, and 500 tablets; 5 mg., bottles of 50 tablets.

SHARP & DOHME

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VOL. 37-A, NO. 6 DECEMBER 1955

The Journal of
Bone and Joint Surgery
*American Volume*

# CONGENITAL ABSENCE OF THE RADIUS *

BY DANIEL C. RIORDAN, M.D., NEW ORLEANS, LOUISIANA

In persons with congenital absence of the radius, the involved upper extremity is characterized by radial deviation of the hand, marked shortening of the forearm, and generalized underdevelopment. A method of effecting and maintaining the correction of this severe deformity has been developed by the author. This method is similar to that proposed by Starr in that a fibula and its epiphysis is used for the bone graft. It is very different from Starr's method, however, in that surgical release of the carpal bones is performed in order to place the hand in its proper relationship to the distal end of the ulna. The author has used this method for five years and can report a five-year follow-up for one case. Eleven patients with congenital absence of the radius have come under his observation. One of these patients died as a result of an associated condition, two patients have been completely lost to follow-up, and two patients have been treated very recently. The remaining six patients have been followed for satisfactory lengths of time, and their cases are reported in detail.

Although this deformity is uncommon, it is not rare. One of the earliest reports of a case was made by Petit in 1733, and numerous other reports have been added to the literature since that time. The most informative report perhaps was that made by Kato in 1924. In this report Kato reviewed the 250 cases that he was able to find in the literature and described three additional cases. In the available literature written since 1924, the author has been able to find another fourteen cases. These and the seven cases that the author has followed himself bring the total number of cases reported to 274.

In reviewing the literature on this deformity, the author was struck by the fact that few have been treated in early childhood, the majority having been treated in late childhood or early adult life. The author's work leads him to believe that early correction is possible and that persons with this deformity should be treated even earlier than were those whose cases are reported here.

Three objectives should be achieved if the person with this deformity is to benefit fully from the treatment. The first objective is the correction of the marked radial deviation of the hand, the second is the improvement of the function of the entire extremity, and the third is the promotion of growth.

## TYPES OF DEFORMITY

There are two main types of this deformity. In the first there is complete and total absence of the radius. A little more than 50 per cent. of the reported cases are of this type. In the second there is only a partial absence of the radius. The most common form of this type is that in which the distal end is defective. The diaphysis or the proximal end of the radius may also be absent, but these two forms have not been observed by this author.

---

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Los Angeles, California, January 28, 1955.

The radial deviation of the hand on the forearm may vary from 30 degrees to over 90 degrees. The greater the deviation is, the less effective the muscles of the forearm are, due to greater relaxation. Thus, the range of motion and the strength of the fingers decreases as the deformity increases.

Those persons with total absence of the radius usually show the most severe deviation of the hand and, therefore, have the least function. In some of these patients, the hand forms an angle of 90 degrees or more with the forearm and may be laid directly against and parallel to the upper arm when the elbow is flexed.

In addition to the radial deviation of the hand, the forearm is shortened. The ulna is usually short and hypertrophied and in most cases is curved with the concavity toward the radial side. In unilateral cases the hand and upper arm are usually smaller than the normal hand and upper arm, and the shoulder girdle is usually underdeveloped in comparison with its normal counterpart.

## ASSOCIATED DEFORMITIES

Whether the radius is partially or completely absent seems to have no bearing on which of the commonly associated deformities are also present. In many of the cases reported in the literature there were multiple severe deformities involving one or all of the extremities. In all of the cases reported here the deformity was unilateral and the remaining extremities were normal. The incidence of bilateral absence of the radius among the reported cases is roughly 50 per cent. In the unilateral cases reported, the right side was affected nearly twice as frequently as the left.

Numerous other associated congenital deformities have been mentioned in the literature; these include harelip, cleft palate, club-foot, hydrocephalus, hernia, kyphosis, scoliosis, torticollis, and rib deformity or fusion of the ribs. An associated deformity which has not been mentioned in the literature but which was found in three of the cases reported here is aplasia or collapse of the lung on the affected side (Fig. 4). In the three patients with this deformity, the right upper extremity was involved, and the right lung was underdeveloped or was not present. In each patient there was dextrocardia and deviation of the trachea to the affected side and also a rib deformity including fusion of the ribs. In one patient there was a hemivertebra of the upper thoracic region with an extra rib on the involved side.

Changes in the skeletal, muscular, and nervous structures frequently occur in association with congenital absence of the radius. A rather definitive summary of these changes was made by Kato in his 1924 report, and in some of the following passages the author has taken advantage of this summary.

The skeletal changes which occur in the involved upper extremity usually involve most of the bones. The scapula is commonly reduced in size, and the clavicle is apt to be shorter and more curved than the normal. The humerus is usually shorter than the normal, and either end may be partially deformed. The carpal bones are rarely complete in number; most frequently absent is the navicular, which also may be fused to other bones. Next most commonly absent is the greater multangular. The capitate, hamate, triquetrum, and pisiform are usually present. Most commonly the first metacarpal is absent, but occasionally it may be present, while the thumb which is frequently absent may occasionally be present (whether or not the first metacarpal is present). If the first metacarpal is absent, the thumb usually has no function and very often is a soft-tissue appendage.

The muscles are frequently involved in the deformity. The pectoralis major may have an abnormal insertion or its clavicular or costal parts may be absent. The pectoralis minor is commonly present and so is the deltoid, although this muscle may have an abnormal insertion or may fuse with the triceps or the brachialis. The biceps is frequently absent. If it is present in a patient with complete absence of the radius, it inserts into the lacertus fibrosus. It is sometimes fused with the brachialis or coracobrachialis, and there is great variability in the size and shape of its two heads. The brachialis is likely to be present but is occasionally rudimentary or absent, while the triceps is likely to be normal. The brachioradialis is usually absent when the radius is completely absent; in other cases it may insert into the ulna. The extensor carpi radialis longus and brevis may be absent, or they may be fused with the extensor digitorum communis, which is usually present and essentially normal. The supinator is commonly absent, unless the proximal radius is present. If the thumb and first metacarpal are present, the extensor pollicis longus and brevis and the abductor brevis are also present, and the muscles of the thenar eminence are usually essentially normal; if the first metacarpal is absent, however, these muscles are commonly also absent. The pronator teres may be absent if the radius is completely absent, or it may be underdeveloped if the radius is partially absent. For the most part the remainder of the flexor muscles of the fingers and wrist are normal, but occasionally they may fuse to one another in various combinations. The flexor pollicis longus is apt to be absent, unless the entire thumb and first metacarpal are present, in which case it is likely to be normal. The pronator quadratus is usually completely absent; the interossei, lumbricales, and hypothenar muscles are usually normal.

The arterial system of the involved upper extremity is frequently abnormal, as one would expect with this type of deformity. The brachial artery is often normal but may divide into two branches high in the arm. The ulnar artery is usually normal, but the radial artery may be small or absent. For the most part the interosseous arteries are well developed.

The nerve supply in the brachial plexus and upper arm of the involved extremity is commonly normal. The radial nerve frequently terminates at the elbow, however, and if it does so, the median nerve provides the sensory distribution on the radial aspect of the hand and anastomoses with the sensory branch of the ulnar nerve on the dorsal aspect of the hand. Frequently, the median nerve is the most superficial structure found on the radial aspect of the forearm. For the most part the ulnar nerve is normal and supplies the usual number of muscles in the hand; but its condition may vary, as it does in the normal individual.

Fanconi's syndrome, a condition that should be looked for in any child with multiple congenital anomalies, is occasionally found in children with congenital absence of the radius. This syndrome is characterized by a severe, progressive, refractory, macrocytic anaemia, and also by neutropenia and thrombopenia, and by hypoplastic bone marrow. There is usually a generalized brown, melanin-like pigmentation of the skin; and associated with this condition are multiple congenital anomalies, including hypogenitalia, genitourinary tract abnormalities, strabismus, gynecomastia, and congenital heart disease. Bone abnormalities, especially of the forearms and thumbs are also quite common. Cassimos described a child with multiple deformities typical of Fanconi's syndrome, including complete absence of the radius and thumb on the right arm and hand and absence of the thumb on the left hand. A child hospitalized by the author for treatment of congenital absence of the radius was found, upon examination, to be suffering from the hypoplastic anaemia of Fanconi's syndrome. Because of this diagnosis no treatment was instituted, and within one year's time the child died.

## EMBRYOLOGY

Among the man ytheories that have been advanced to explain this deformity, one of the most interesting is the archipterygial theory of Gegenbaur. Gegenbaur assumes that the vertebrate limb is derived from the skeletal system of the primitive fin (archipterygium) of the Dipnoan fish. According to this theory, as discussed by Kato, the upper extremity is composed of a main stem and four accessory rays. The main stem includes the humerus, the ulna, two carpal bones, the fifth metacarpal, and the three phalanges of the little finger. The first accessory ray includes the radius, navicular, greater multangular, first metacarpal, and two phalanges of the thumb. The index finger, the long finger, and the ring finger, with their respective metacarpals and carpal bones, constitute the second, third, and fourth accessory rays. In this view it is assumed that the bony defect is always due to a suppression, in regular order, of one or more of these accessory rays. When the first accessory ray is completely suppressed, the result is congenital absence of the radius, first metacarpal, and thumb. If only part of the first ray is missing, it is thought that the result is a coalescence of the two bones of the forearm. The difficulty with this theory is that it does not explain the associated abnormalities which involve the entire upper extremity, including the ribs and lung.

It has been demonstrated experimentally that abnormalities of the bones of the extremities can be produced by maternal nutritional deficiency. Warkany, Nelson, and Schrassenberger observed that in rats maternal nutritional deficiency altered the precursors of the bones in their cartilaginous or precartilaginous stages and that bony defects occurred as the secondary results of this faulty development.

## METHOD OF TREATMENT

It goes without saying that non-operative measures should precede operative treatment. In the correction of the deformity plaster casts, splints, or braces should be used until the soft tissues have been stretched to the greatest degree that the bony deformity will allow; it is advised that plaster-cast correction or splint correction be started as soon after birth as it is feasible. The operative procedures described in the literature seem to be confined to tenotomy of the contracted muscles, osteotomy of the curved ulna, addition of a stabilizing bone graft to replace the absent radius, or splitting of the ulna into radial and ulnar portions.

The first step in the author's method is to overcome the deformity as much as possible by stretching the soft tissues by a series of corrective plaster casts. In one case, after the soft tissues had been stretched in this manner, a small metal brace was applied to maintain the correction of the deformity until the surgical treatment was started.

The second step, and a very important one, is the surgical release of the carpus and the placing of these bones and of the hand over the distal end of the ulna. Experience has shown that the hand can never be brought into normal relationship by traction or by gradual stretching with plaster casts. The carpal bones will remain proximal to the distal end of the ulna unless complete surgical release of the soft tissues around both these structures is performed. When these structures have been exposed from both the radial and ulnar sides, however, the hand may be placed over the distal end of the ulna. (In no case in the author's series was it necessary to tenotomize any of the musculotendinous structures.) The hand is maintained in the corrected position by means of Kirschner wires which are easily inserted (and easily removed) and by plaster-cast immobilization. Approximately two to three months following the repositioning of the hand, osteotomy of the ulna to correct bowing may be performed, if necessary. This procedure will not always be necessary, however, for the ulna is not always curved. The final step in this method is the addition of a stabilizing factor on the radial side of the forearm. It was decided to try the method developed by Starr, who transplanted the proximal end of the fibula to replace the distal end of the absent radius. (This method has been used by the author in ten patients. Two of these were subsequently lost to follow-up, however, and so their cases are not reported here. In two of the eight patients who were followed there was partial absence of the radius, and in six there was complete absence of the radius.) The proximal end of the fibula, including its proximal epiphysis, is removed, along with two or three inches of bone from the shaft. The length of the graft depends upon the age of the child. In a very small child of two years or less, two inches of bone is adequate, while in an older child, more bone will be necessary. Through the exposure made on the

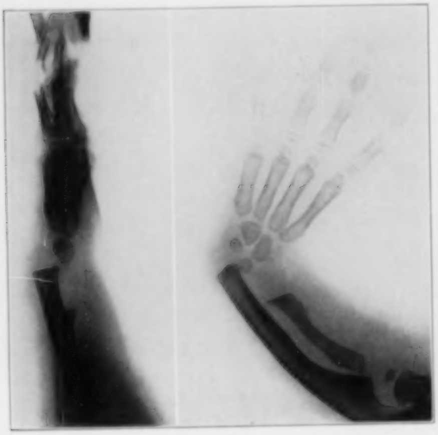

FIG. 1-A

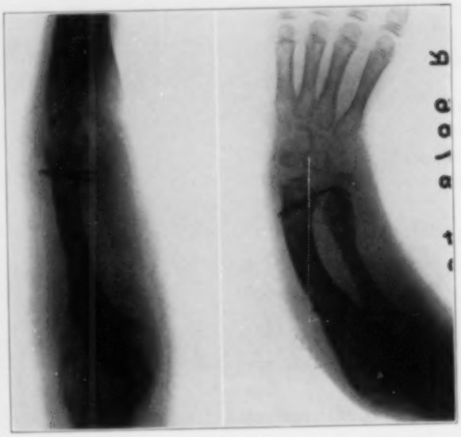

FIG. 1-B

Fig. 1-A: The preoperative appearance in a case of partial absence of the radius.

Fig. 1-B: A homogenous fibular graft in place, fixed by Kirschner wires.

Fig. 1-C: The result one and one-half years after the insertion of a fibular graft.

Fig. 1-D: Left: the preoperative appearance. Right: the postoperative appearance.

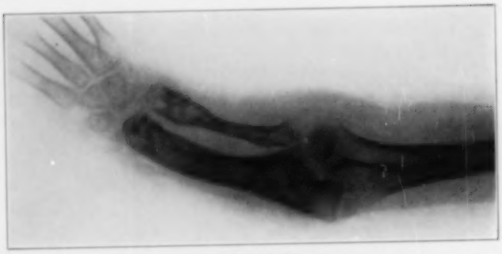

FIG. 1-C

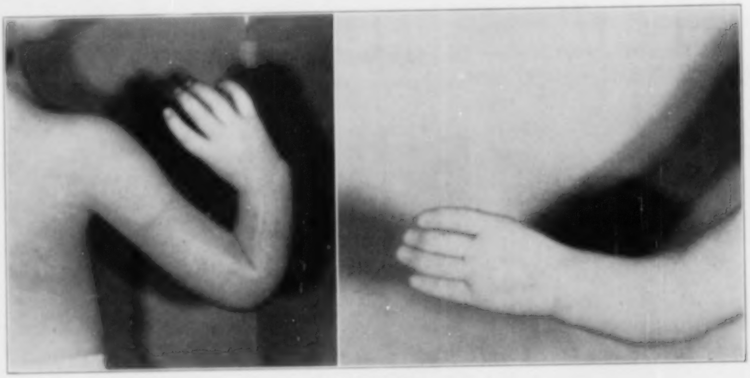

FIG. 1-D

radial side of the wrist, the flexor and extensor structures are identified and separated, and the fibula is placed in the position of the absent radius and is directed obliquely against the ulna. Two methods of fixation can be used. In one, a long spike of bone is turned down on the ulna forming a V-shaped notch into which a similar, but oppositely placed spike of bone on the fibula is fitted. In the other method, the ulna is osteotomized (a procedure which helps to correct any bowing of the ulna) and the fibula is placed against the raw surface of the ulna. A Y-shaped bony structure is thus formed on the forearm. Both of these methods have been satisfactory. It is common knowledge that solid fixation of the graft is necessary; otherwise, the graft may become absorbed, as seems to have happened in patients treated by Ryerson and Antonelli. These men placed bone grafts in the soft

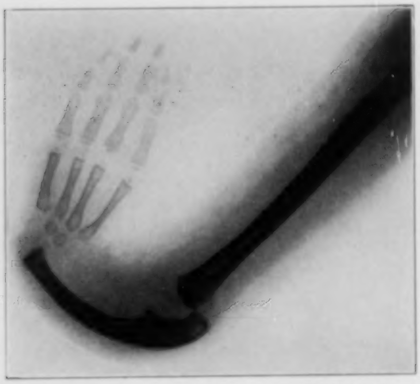

FIG. 2-A

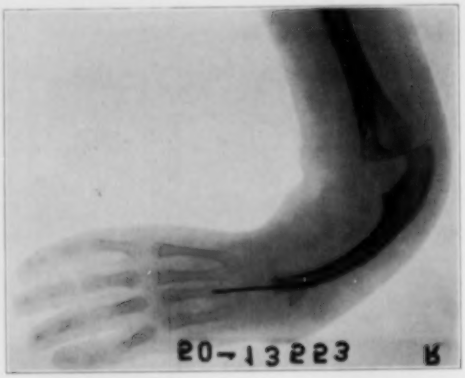

FIG. 2 B

Fig. 2-A: The preoperative appearance in a case of total absence of the radius.

Fig. 2-B: The appearance after surgical placement of the hand in its proper position.

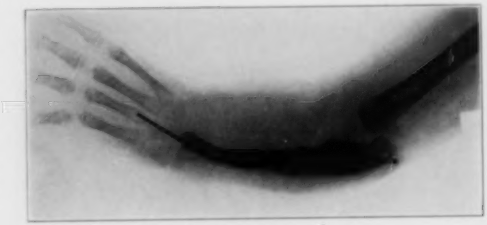

FIG. 2-C

Fig. 2-C: The appearance after osteotomy of the proximal ulna.

Fig. 2-D: The fibular graft in place; the end of the graft is held in place by Kirschner wires.

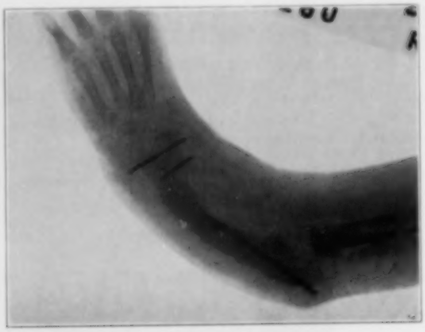

FIG. 2-D

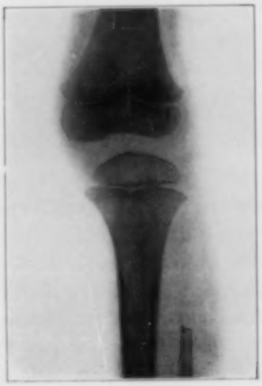

FIG. 2-E

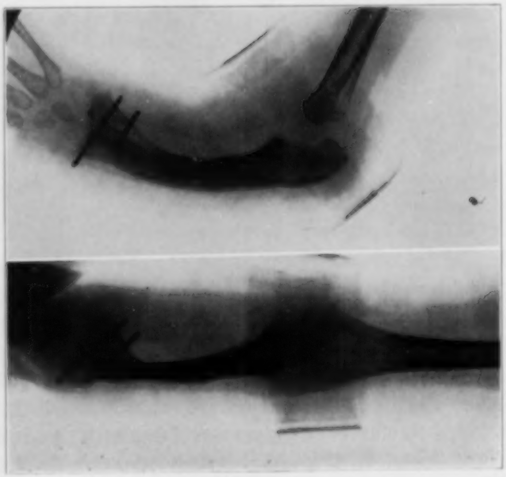

FIG. 2-F

Fig. 2-E: The donor site of a fibular graft.

Fig. 2-F: The epiphysis measured one-eighth of an inch in diameter two months postoperatively.

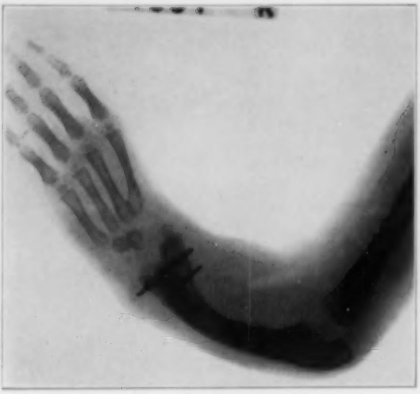

FIG. 2-G

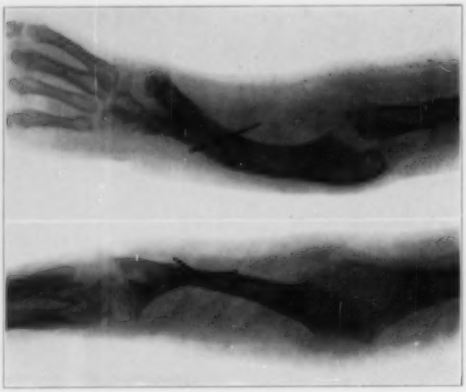

FIG. 2-H

Fig. 2-G: The epiphysis measured one-fourth of an inch in diameter six months postoperatively.

Fig. 2-H: The epiphysis measured one-half of an inch in diameter five years postoperatively.

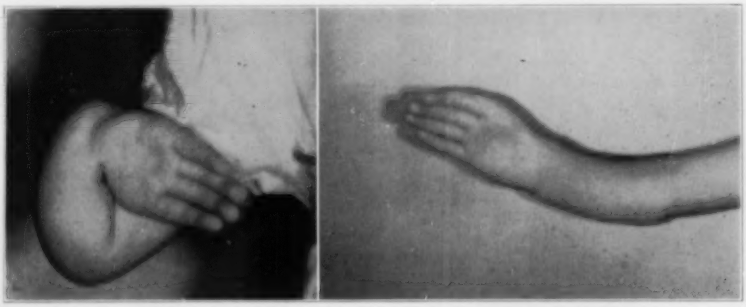

FIG. 2-I

Left: the preoperative appearance. Right: the appearance five years after operation.

tissues of the forearm without securing good stabilization; and later, as shown by roentgenograms, the grafts were greatly absorbed. In one of the cases reported here partial absorption of the graft occurred, as will be described later.

### CASE REPORTS

Two patients with partial absence of the radius have been followed. One of these patients was lost to follow-up a short time ago, but, when last seen the correction of the deformity was fairly satisfactory. The other child (Fig. 1-A) has been followed up to the present time and represents a one year follow-up.

In this case the graft material was taken from a one-year-old child in whom an amputation of both legs by disarticulation at the knee had been performed because of severe arthrogryposis. The proximal portion of the fibula from one leg of this infant was removed and was immediately transplanted into the forearm of the child with a partially absent radius. The epiphysis of this fibula was undeveloped at the time of implantation and did not show on subsequent roentgenograms (Fig. 1-B). At a later date, during a minor procedure (removal of the pins that were used to transfix the fibular graft), it was found that this epiphysis had become completely loose in the soft tissues and that it had all the appearance of a sequestrum. Being useless, it was removed, and because of its lack, the child will probably need further correction as growth continues. Other than this complication, the results of the graft operation were good. The bone of the fibula survived or was replaced by new bone and satisfactory restoration of length of the radius was accomplished (Figs. 1-C and 1-D). Microscopic sections of the removed epiphysis showed what appeared to be normal cartilage cells.

In the remaining patients who have been followed, the radius was completely absent. The patient in this group with the longest follow-up was originally seen at the age of two (Fig. 2-A).

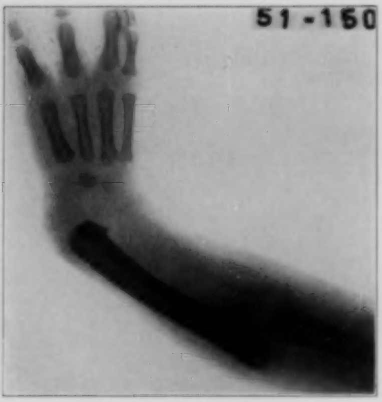

FIG. 3-A

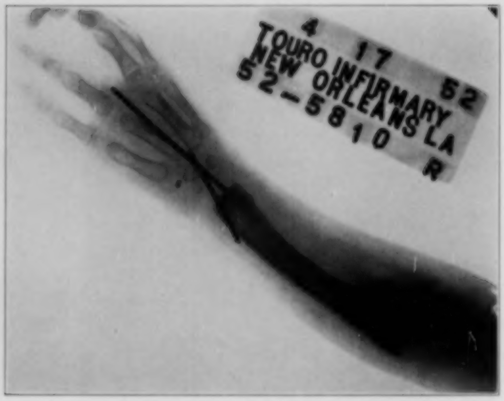

FIG. 3-B

Fig. 3-A: The preoperative appearance in a case of total absence of the radius.

Fig. 3-B: The appearance after surgical placement of the hand in its proper position.

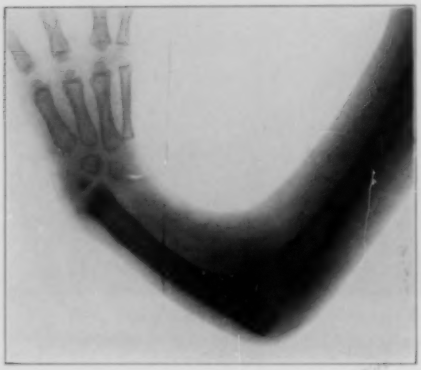

FIG. 3-C

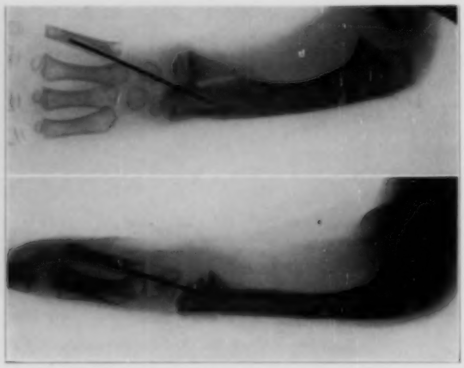

FIG. 3-D

Fig. 3-C: A roentgenogram showing the recurrence of the radial deviation of the hand.

Fig. 3-D: The position of the hand has been restored and maintained by a fixed fibular graft.

Fig. 3-E: The fibular graft twenty-two months after transplantation. The epiphysis appears to be fusing to the shaft.

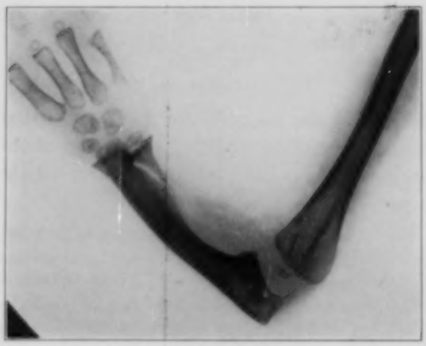

FIG. 3-E

In this patient, plaster-cast correction of the deformity was initiated at this time, and six months later the first stage of the surgical correction, re-positioning of the hand, was done (Fig. 2-B). The second stage in this case was an osteotomy of the ulna, proximally, performed in order to correct a rather marked C-shaped deformity (Fig. 2-C). The next step was the implantation of a free graft. For this graft the proximal end of a fibula taken from one of the patient's legs was used (Figs. 2-D and 2-E). Figures 2-F, 2-G, and 2-H show that later there was a progressive increase in the length of this fibula. It is difficult to measure the growth of a fibular graft, for the proximal end of the graft becomes fused into the ulna and it is hard to locate the original end of the graft. In this case, however, by using a standardized technique to measure the fibula as it appeared on roentgenograms, the authors found that the growth of the bone had been one-half of an inch. This measurement corresponds exactly to the size of the epiphysis and, therefore, the increase in the length of this fibula appears to be due to ossification of the epiphysis rather than to actual growth of the bone. The epiphysis in this patient now appears to be fused to the shaft of the fibula, having remained open for nearly five years (Fig. 2-I).

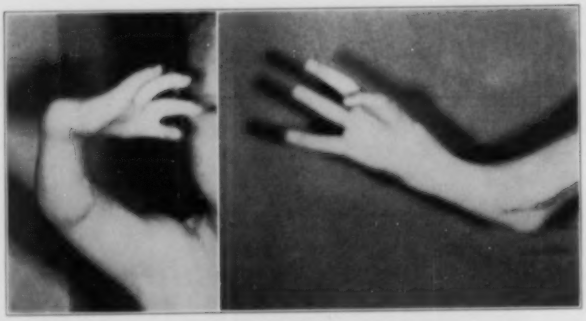

FIG. 3-F

Left: the preoperative appearance. Right: the appearance three years after the start of treatment.

The second patient with complete absence of the radius who has been adequately followed-up was a white male child in whom treatment was started in 1952, when he was three years of age (Fig. 3-A). Plaster-cast correction was used to stretch the soft-tissue deformities, and the carpal bones were then placed over the distal end of the ulna (Fig. 3-B). A capsuloplasty on the elbow was performed in order to gain some flexion. Since the ulna in this case was quite straight and was very broad at its distal end, it was hoped that it would be able to support the carpal bones. In spite of immobilization, both with plaster casts and with a small brace, however, the hand slowly slipped to the radial side (Fig. 3-C); and after a year it became obvious that a support on the radial side of the forearm was necessary. In February, 1953, the deformity was recorrected and the proximal end of the fibula from one of the child's legs was removed and was placed between the flexor and extensor structures against the carpal bones (Fig. 3-D). Originally visible, the epiphysis behaved much as had the one previously described. It increased in size until it was fully developed, at which time it appeared to fuse to the shaft of the fibula. Roentgenograms made twenty-two months after transplantation showed that the epiphysis was completely united with the shaft of the fibula (Fig. 3-E). A cross union between the fibula and the ulna developed, and the edge of the fibula proximal to the union began to be absorbed as shown by the roentgenograms. In this child there was a complete absence of the thumb, and the index finger was abnormal, being curved and in front of the long finger. Since this condition inhibited motion of the long finger, a thumb was reconstructed by rotation of the deformed index finger and by application of an abdominal flap in the web. At a later date, an opponens transfer was performed, the sublimis tendon and the muscle belly of the ring finger being used as the motor power for the opponens. The cosmetic result of this operation was excellent considering the original deformity, and the function of the hand was tremendously improved (Fig. 3-F).

A third patient with complete absence of the radius was a four-year-old white girl in whom the first metacarpal was absent, the thumb being present as a soft-tissue appendage. Plaster-cast correction was utilized, and the hand was then surgically repositioned over the distal end of the ulna. This latter procedure took such a short time that it was decided to transplant the fibula during the same operation. Four weeks later an osteotomy of the ulna was performed, and iliac bone chips, taken from the child's mother, were placed around the site of the union of the fibular graft and the ulna. At this stage the roentgenograms showed satisfactory progress. Three months later, however, the iliac grafts had been absorbed and the proximal end of the fibula had become loose in the tissues. It was necessary to place the fibula in a new bed in the ulna. Recent roentgenograms show that the fibula is now firmly united to the ulna.

A fourth patient in whom there was complete absence of the radius on one side was a Negro male, aged four. The thumb and first metacarpal were present. After plaster-cast correction, repositioning of the hand was done and a fibula graft was implanted. Unfortunately, this graft was accidentally destroyed and so, to take its place, the distal portion of the ulna was split after the method of Bardenheuer. To date, the hand has maintained reasonably good correction, although no growth has occurred.

## RESULTS

A satisfactory correction of the cosmetic deformity was obtained in all the cases that have been adequately followed. General experience in these cases and also in others shows that it is necessary to replace the absent radius with bone fixed to the ulna in order to prevent recurrence of the deformity after correction. In these cases, as in those of Starr, good wrist motion was obtained, no attempt having been made to fuse the carpal bones to the distal end of the new radius. To date, this good wrist motion has been maintained. The longest period of follow-up so far is five years, the next longest being three years.

Originally it was hoped that actual increase in bone length could be gained by transplanting a growing bone. True bone growth was not obtained in these cases, however,

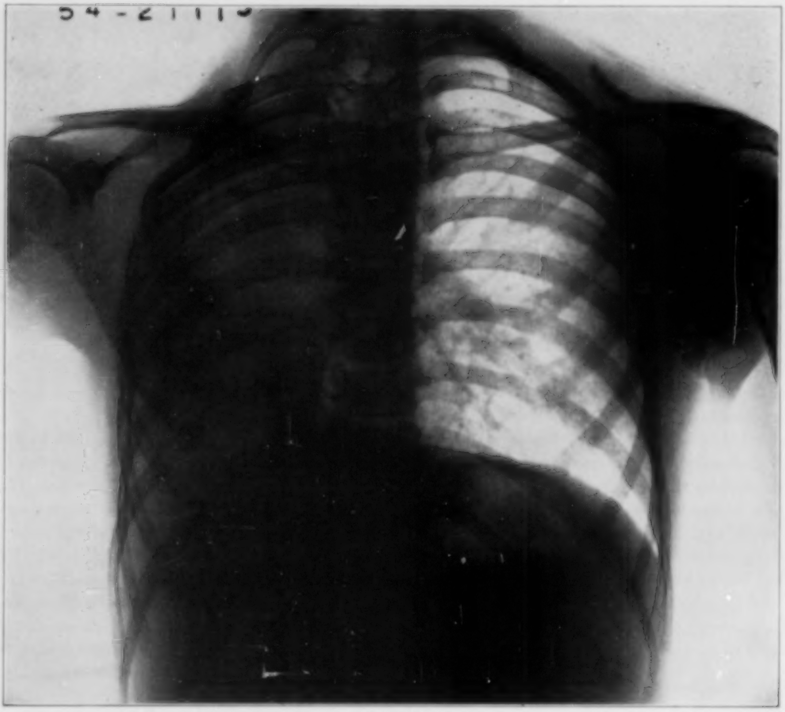

Fig. 4

A roentgenogram of the chest, showing aplasia of the right lung and dextrocardia.

for the increase in length that is apparent on the roentgenograms is simply the result of ossification of the cartilaginous epiphysis. Measurements of the grafts in the patients with the longest follow-up appear to bear out this supposition.

In patients surgically treated when one year of age or less, there may be a better chance of obtaining true bone growth. It is well known that the earlier surgery is performed in a child, the better the result will be and the more quickly this result will be obtained, for the growth potential of a very young child is great.

In some cases it may be necessary to osteotomize the ulna at both the distal and proximal ends in order to correct an extreme curvature of this bone. Osteotomy of the ulna may also be necessary at a later date to prevent recurrence of the deformity due to the growth of this bone without corresponding growth of the fibular graft. To date, in the author's cases, osteotomy for the latter reason has not been necessary. In the patient who has been followed for five years, however, the curve in the ulna seems to be gradually increasing and eventually an osteotomy may have to be done.

A gratifying improvement in the range of motion and in the strength of the involved finger flexors and extensors can be obtained by the author's method of treatment. This improvement is probably due to the stabilization of the carpus and hand and to the stretching of the muscles. When the carpal bones and, therefore, the hand have been stabilized, the action of the muscles can be transferred to the fingers. In all the cases treated by the author, excellent improvement in the range of motion and in the strength of the flexor and extensor muscles was obtained.

Pronation and supination cannot be made possible in patients with complete absence of the radius. In those with partial absence, however, limited pronation and supination can be made possible. In the latter patients the carpal bones are placed in a neutral position after which the patient may easily obtain pronation and also some supination by abduction of the shoulder.

In only one patient has an attempt been made to reconstruct a thumb. In this patient the index finger, which was deformed and essentially functionless, interfered with the function of the adjacent long finger. Fairly satisfactory function in the reconstructed thumb was obtained (Fig. 3-F), and improvement in the range of motion of the long finger resulted when the index finger which blocked its motion was removed. In this author's opinion, a thumb should never be reconstructed in patients in whom the deformity is unilateral. It is true that most of these patients will use a pinching mechanism held between the index and long fingers, and it is understandable that the surgeon would be tempted to swing the index finger around in order to make a thumb. It is felt, however, that a hand without a thumb but with four well functioning fingers is more able to assist a normal hand than is a hand with only three normal functioning fingers and an abnormal thumb. It is also felt that the cosmetic appearance of a hand with four normal fingers and no thumb is better than that of a hand with three normal fingers and an abnormal thumb. In a bilateral case, the author feels that a thumb should be reconstructed on one side. If indicated, a thumb could, of course, be reconstructed on both sides.

In no patient treated by the author has any harm resulted from the removal of the proximal end of the fibula. In every case the knee has remained stable, the growth of the remaining fibula has not been disturbed, and the distal end of the fibula has maintained its normal relationship with the tibia and ankle joint. Care was always taken at the removal of the graft to preserve the fibular collateral ligament of the knee.

Two patients have been treated by the author very recently. In one of these patients the deformity was bilateral, there being complete absence of the radius and thumb on both sides. Both hands have been surgically repositioned, and fibular grafts have been inserted. It is planned to reconstruct a thumb on one side.

In the second patient who was treated very recently, there was complete absence of the radius and thumb. Treatment was started when the patient was ten days old. The hand was repositioned when he was five months old and the graft inserted when he was six and one-half months old. It is too early to draw any conclusions from these cases.

## REFERENCES

1. ANTONELLI, I.: Su un caso di mancanza congenita bilaterale del radio. Gazz. Med. Italiana, Torino, **55:** 501–513, 519, 1904; **56:** 81, 1905.
2. CASSIMOS, CHRISTOS, and ZANNOS, LEDA: Congenital Hypoplastic Anemia Associated with Multiple Developmental Defects (Fanconi's Syndrome). Am. J. Dis. Child., **84:** 347–350, 1952.
3. GEGENBAUR, C.: Zur Morphologie der Gliedmassen der Wirbelthiere. Morph. Jahrb., **2:** 396, 1876.
4. KATO, KATSUJI: Congenital Absence of Radius. J. Bone and Joint Surg., **6:** 589–626, July 1924.
5. PETIT, J. L.: Remarques sur un enfant nouveau-né, dont les bras étaient difformés. Paris, Mem. d. l'Acad. Roy. d. Sci., p. 17, 1733.
6. STARR, D. E.: Congenital Absence of the Radius. A Method of Surgical Correction. J. Bone and Joint Surg., **27:** 572–577, Oct. 1945.
7. WARKANY, JOSEF; NELSON, R. C.; and SCHRAFFENBERGER, ELIZABETH: Congenital Malformations Induced in Rats by Maternal Nutritional Deficiency. III. Malformations of the Extremities. J. Bone and Joint Surg., **25:** 261–270, Apr. 1943.

## DISCUSSION

**DR. STERLING BUNNELL, SAN FRANCISCO, CALIFORNIA:** Clinarthrosis or radial club-hand usually occurs in association with defect of the radius, but it may also be present when the radius is intact. Clinarthrosis and a defect of the radius are merely manifestations of a defect in the radial elements of the limb bud. Similarly clinarthrosis or ulnar club-hand usually occurs in association with defect of the ulna. O'Rahilly [b], who tabulated many cases, found that the dividing line between radial and ulnar hemimelias lies along the index finger, cases differing slightly as to just which parts of the anatomy are present along this line as it is prolonged up the limb. The last three fingers are often absent in a case of a defect of the ulna, and the thumb is often absent in a case of defect of the radius.

Mirror hand is often the result of defect of the radius and thumb and is frequently associated with radial clinarthrosis.

Dr. Riordan succeeded in straightening the wrist by starting treatment very early, first applying plaster casts and then surgically placing the hand on the end of the ulna and inserting a bone graft. My experience has been similar to his. It has been difficult to maintain a correction obtained by casts and braces, but once the wrist has been surgically positioned, a simple straight gutter splint on the hand and forearm has held it in place.

I make a large Z-plasty on the concave side to change breadth to length, sometimes even supplementing this procedure by a skin graft. During this procedure all binding structures are severed, including the deep fascia and all the restraining tendons that do not go to the digits, and finally capsulotomy of the wrist is performed. Considering that arthrodesis will be the usual result, tenotomy of the wrist tendons is relatively harmless; if a moveable wrist is desired, however, both the wrist tendons and the digit tendons may be elongated instead of severed.

Operation should be deferred until the second year when the arm is more developed. A straight gutter splint may be applied. This splint will allow the arm to function in a manner that will encourage it to grow until it is ready for the bone operation. A wrist mounted on the ulna and supported by a bone graft lacks stability, and it would seem that arthrodesis should be performed at a later date in order to achieve stability. Dr. Riordan found that unfortunately the bone graft does not grow. There is much evidence that grafted epiphyses do not grow, as was early determined by Sylvan Haas [a], while there are only a few scattered reports of cases indicating that they do.

a. Haas, Sylvan: Personal communication.

b. O'Rahilly, Ronan: Morphological Patterns in Limb Deficiences and Duplications. Am. J. Anat., **89:** 135–194, 1951.

Dr. Joseph H. Boyes, Los Angeles, California: It is a privilege to discuss this review by Dr. Riordan describing his improvement in Starr's technique of correcting and maintaining alignment of this deformity. I have examined Dr. Riordan's oldest patient and also have seen a patient in whom a similar transplant was done six years ago by Mr. Guy Pulvertaft in Derby, England. My own experience is limited to two patients. In one, the procedure has been completed; in the other the final transplant has not yet been performed.

I believe the most important point in Dr. Riordan's presentation, and the one I would stress, is that the correction of the alignment of the carpus by surgical release should usually, if not always, be performed as a separate preliminary operation before the fibular transplant is performed. This surgical release is only accomplished by the thorough detailed division of the ligaments and even of some of the tendons at the wrist. It is not simply a loosening of the skin on the medial side to correct an angular deformity but is a definite shift of the hand and carpus on the ulna. Osteotomy of the ulna may or may not be done then as a second stage, but if it is necessary, it should precede the fibular transplant. Dr. Riordan's paper mentions one instance of Fanconi's syndrome, which was unfortunately present in my first case.

Dr. Riordan (closing): Dr. Boyes mentioned one topic which I wish to stress again, and that is, if you treat this deformity early, it is not necessary to operate on the tissues for tightness later. The tissues should be stretched as much as possible first, and after that the hand should be surgically replaced over the distal end of the ulna. The skin is tight at this stage, but that can be overcome simply by flexing the elbow. After the wound has healed, the elbow is gradually straightened, the ulnar deviation of the hand being still maintained, and in that way the skin is stretched. Dr. Boyes described cases in which he did temporary end-to-end nerve sutures with the elbow flexed. Later he gradually straightened the elbow and then did his nerve repair. We follow the same principle in stretching the skin.

Dr. Haas showed a case in which the epiphysis was open after six years and in which there was measurable bone growth. I am convinced after seeing Dr. Graham's proximal phalangeal joint transfer that growth can be obtained in a free bone graft if the graft is small enough and if the child is young enough. Patients with this deformity should be treated early; do not postpone treatment, as the literature recommends.

Dr. Bunnell said that he thought wrist fusion might subsequently be necessary. I have not had to fuse the wrist in any of the patients I have treated, but I have not had experience enough to come to any final conclusion on this point.

# RECONSTRUCTIVE SURGERY OF THE HAND IN CEREBRAL PALSY AND SPASTIC PARALYSIS RESULTING FROM INJURY TO THE SPINAL CORD *

BY J. LEONARD GOLDNER, M.D., DURHAM, NORTH CAROLINA

*From the Duke Hospital, Duke University School of Medicine, Durham*

Reconstructive surgery for hand deformities resulting from cerebral palsy or trauma to the cervical cord is uncertain treatment. Operative procedures which have proved highly satisfactory for the treatment of flaccid paralysis resulting from infection or trauma are not as satisfactory when used in the presence of spasticity or athetosis. To relegate spastic hands to treatment by splinting, stretching, and muscle re-education alone, without including surgery, is to overlook procedures which will give satisfactory results in selected cases and which will give moderate but sufficient improvement in others. *The majority of hand deformities resulting from cerebral palsy do not warrant surgery* [11]. In selected cases, however, surgery combined with splinting, stretching, and muscle re-education may aid in rehabilitation. The operative procedures are more likely to be successful in the cerebral spastic and in the patient who has developed spasticity following injury to the spinal cord than in those with other forms of cerebral palsy.

The plan for improving the use of the upper extremities should be arranged so that the better hand is made dominant as early as possible. The weaker hand should be trained as a helper [14]. Such mundane activities as dressing, eating, tying shoes, sweeping, drying dishes, playing marbles, fishing, plowing, and writing are accomplished more easily with the aid of a "helping hand". If reconstructive surgery offers improvement in the performance of these activities, it is justified. Careful selection of cases will increase the possibility of a greater number of satisfactory end results. Of 800 patients under the age of eighteen years who were examined at the North Carolina Cerebral Palsy Hospital during the past three years, 300 were found to be eligible for general treatment after consideration of their mental and physical condition [1]. Only twelve patients (4 per cent.) of the selected 300, however, were considered eligible for hand surgery. A few more of the 300 patients may become eligible for surgery when they are older. In addition, five patients with residual spasticity following injury to the cervical cord have been operated upon. The duration of follow-up since completion of surgery has been approximately three years.

## CHOICE OF PATIENTS FOR SURGERY

Screening has consisted of the various standard psychological tests and of physical examination of the patient. In this particular group of 800, those classified as not being eligible for treatment may have been mentally deficient or they may have had such severe general involvement that therapy was not indicated or such mild involvement that treatment was not considered necessary. Of the 300 chosen for general in-patient treatment, only twelve were selected for hand surgery. The other five patients in this entire series had been left with a deformity or spasticity after specific head injury or injury to the cervical spine.

### *Contra-Indications to Surgery in This Series*

A decision against surgery was usually made on the following grounds:

1. When there was generalized muscle weakness of the extremity with no available motors for adding strength;

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1954. Second revision received for publication April 23, 1955.

2. When the patient had an adequate grasp and release mechanism and there was evidence that stabilization of the wrist would interfere with either opening or closing the fingers;

3. When there was no particular joint deformity about the thumb;

4. When the patient's ability to use the hand seemed to be as good as that which might be expected from surgery;

5. When there was a lack of voluntary control of muscles;

6. When the patient had severe athetosis;

7. When there was excessive hypermobility of all the joints of the hand.

### *Indications for Surgery*

In general, the patients chosen for surgery were required to have an intelligence quotient above 70, although this particular level was not adhered to specifically if certain specific functions could be accomplished by doing the surgery. The decision to do surgery depended upon the patient's ability to show that he had some active flexion of the digits and that, in certain positions, thumb extension could be obtained by adding supplementary motors or by doing arthrodeses. In addition, surgery was performed when specific joint deformities, such as severe flexion deformity of the metacarpophalangeal joint of the thumb, prevented the thumb from being extended from the hand. Tendon transfers, either alone or in conjunction with arthrodesis, were done in those cases in which there was a specific muscle deficit and in which there were strong enough motors available to reduce the deficit.

Thus, surgery was done for those patients who had enough intelligence to follow through with re-education and who had enough initiative to take advantage of the anatomical improvement. The indications for surgery, then, may be found in the six disabling conditions to be discussed. The decision to do surgery depended on the probability of improving function by joint and tendon surgery in the particular hand, depending again on the assets in each hand. The sensory status of each hand was considered carefully.

## SPECIFIC DEFORMITIES AND THEIR TREATMENT

The specific deformities to be discussed are (1) the "thumb-in-palm" deformity, (2) flexion or extension deformities of the index finger, (3) flexion deformities of the long, ring, and little fingers, (4) flexion deformity of the wrist, (5) instability of joints, and (6) localized paralysis of specific muscle groups. In all instances, the goal was to secure a grasp and a release, either active or passive, and to provide or improve the pinch. The operative procedures were done in order to increase function and to simplify or eliminate splinting.

The specific operative procedures used in this group of patients were the following:

1. Arthrodesis of the wrist joint;
2. Arthrodesis of the metacarpophalangeal joint of the thumb;
3. Re-routing of the extensor pollicis longus;
4. Transfer of the wrist flexors to the extensors of the wrist, finger, or thumb;
5. Opening of the thumb web;
6. Opponens transfer;
7. Arthrodesis of the interphalangeal joints;
8. Transfer of the flexores digitorum profundi to the flexores digitorum sublimes;
9. Section of the lateral bands (index finger);
10. Replacement for weakness of the intrinsic muscles to the index finger.

### *Deformities of the Thumb*

The "thumb-in-palm" deformity (Fig. 1) is one of the most disabling deformities seen in the spastic hand. The severity of the flexion and adduction of the thumb can

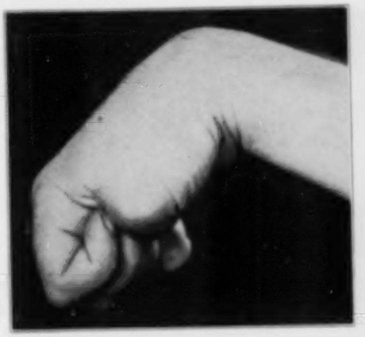

FIG. 1

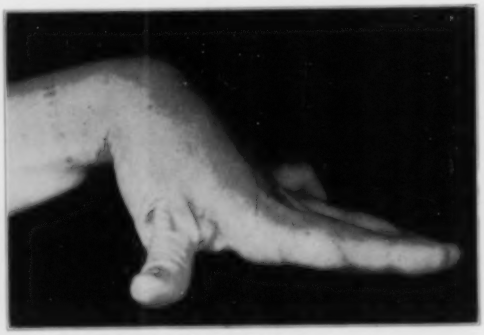

FIG. 2

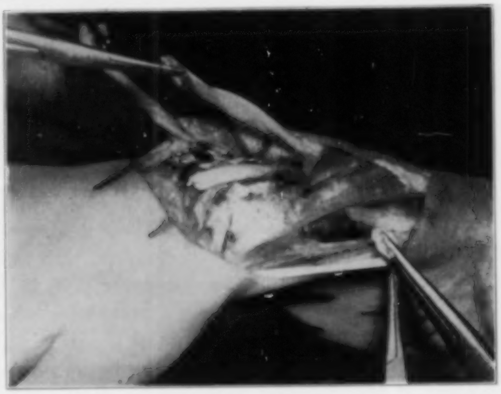

FIG. 3

Fig. 1: Typical deformities seen in a hand in severe cerebral palsy with spasticity. The overactive flexor pollicis longus pulls the thumb into the palm. There is hypermobility of the metacarpophalangeal joint of the thumb. Spasticity is present in all of the finger flexors and wrist flexors. (For the operative result, see Figs. 12-A and 12-B.)

Fig. 2: When this hand is in the neutral position (neither flexed nor extended), the fingers and thumb are clutched tightly in the palm. Voluntary extension of the fingers is difficult with the wrist in the neutral position or in one of dorsiflexion because of the weakness in the extensor digitorum communis and extensor pollicis longus. With the wrist joint in acute flexion, the stretch on the extensor tendons allows the fingers and thumb to be brought out of the palm.

Fig. 3: The extensor pollicis longus has been severed and the distal segment has been re-routed to the radial aspect of the wrist. The extensor carpi radialis longus has been detached from its insertion and will be re-directed and sutured to the re-routed extensor pollicis longus. (The upper hemostat holds the end of the extensor carpi radialis longus. The lower hemostats hold the distal ends of the extensor pollicis longus after it has been cut from the muscle belly.) This will give an extending motor to the thumb or a tenodesis and will diminish the tendency to external rotation.

be mild, moderate, or severe. If the deformity is mild, ulnar deviation of the hand at the wrist will increase the tension of the extensor and abductor mechanism of the thumb and will pull the thumb phalanges and first metacarpal toward the radial side [7]. The extensor pollicis longus acts in conjunction (Fig. 2) with the long abductor and short extensor of the thumb in pulling the phalanges and first metacarpal out of the palm.

If the flexor pollicis longus is spastic, or contracted, or if the thumb web is tight [4], ulnar deviation of the hand will not bring the thumb as a unit out of the palm. In the presence of these severe thumb deformities, a flexed wrist, rather than one in ulnar deviation, makes it possible to "open the palm" (Fig. 2).

Hypermobility of the metacarpophalangeal joint may prevent extension of the phalanages of the thumb. If this joint is loose, either hyperflexion or hyperextension may result, depending on the direction of the strongest pull on the phalanges. When the flexors are strong, the thumb stays in the palm, despite the pull of the extensors. The extensor pollicis longus may have become displaced toward the volar surface of the metacarpophalangeal joint and thus may act as a flexor instead of an extensor; when this displacement occurs, even acute flexion of the wrist will not allow complete extension of the thumb.

Paralysis, or paresis, of the intrinsic musculature of the thumb is another factor leading to the thumb-in-palm position. This weakness allows a strong flexor pollicis

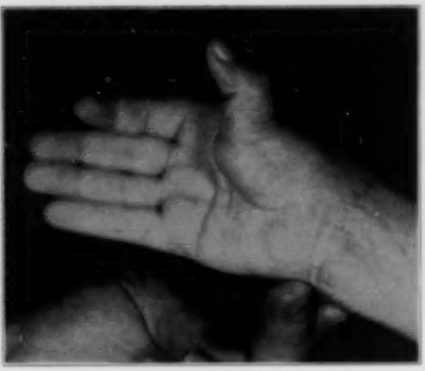

FIG. 4

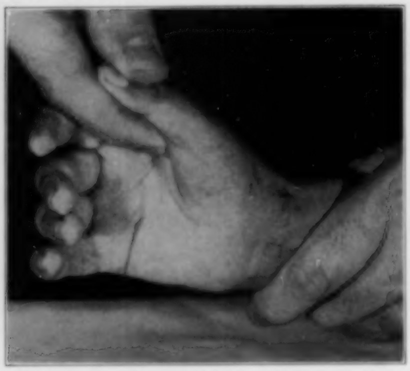

FIG. 5

Fig. 4: Photograph made after tendon transfer. Before operation, there were thumb-in-palm and severe wrist-flexion deformities. Recognition of hypermobility, either in flexion or extension, at the metacarpophalangeal joint of the thumb must be made. If the extensor tendon of the thumb is supplemented and the joint is not fused, a hyperextension deformity will result, as in this hand.

Fig. 5: With the metacarpophalangeal joint held in slight flexion, there is increased tension on the extensor pollicis longus and its effectiveness as an extensor of the thumb is improved. Arthrodesis of the metacarpophalangeal joint of the thumb in this position will aid in keeping the thumb out of the palm. (See Fig. 6-B.)

longus and adductor pollicis to increase flexion of the first metacarpophalangeal joint. Spasticity in or contracture of the thumb web can initiate the thumb-in-palm position. The first dorsal interosseus, the adductor pollicis, or the flexor pollicis longus and brevis may be spastic and hold the first metacarpal close to the second. The tight adductor pollicis increases the flexed position of the proximal phalanx of the thumb.

Tightness of the thumb web, the hypermobile metacarpophalangeal joint, and the weakness of the intrinsic musculature of the thumb lead eventually to external rotation at the carpometacarpal joint. The carpometacarpal joint of the thumb aids in the functions of pinch, grasp, and opposition. For this reason, the stability of this key joint must be controlled by an active extensor mechanism or by a functioning tenodesis.

### *Operations to Improve Thumb Function*

The surgical procedures selected to improve thumb function depend on the specific causes of the deformities.

Arthrodesis of the wrist in slight ulnar deviation may be all that is necessary to get the thumb out of the palm. If the thumb extensor mechanism is inactive, or if it has stretched because of prolonged flexion, transplantation of an active wrist or finger flexor to the extensor pollicis longus of the thumb should be done (Fig. 3). The extensor pollicis longus tendon is cut at the level of the dorsal carpal ligament and the distal segment is re-directed radialward along the line of the abductor pollicis longus. If the flexor carpi radialis, for example, is the transplanted motor, it is sutured under the proper tension to the distal end of the extensor pollicis longus in its new location. This procedure adds an active motor for extension. With the tendon re-routed [12], there is less chance for the thumb to roll into external rotation and adduction. The extensor tendon in this new location increases the stability of the carpometacarpal joint and acts as a tenodesis if active extension does not result.

The metacarpophalangeal joint of the thumb, if unstable, may be fused at the same time the transfer to the extensor pollicis longus is done. The fusion prevents the new extensor motor from hyperextending the metacarpophalangeal joint (Fig. 4). If opposition is weak, the proximal phalanx of the thumb should be rotated toward the palm. The joint should be stabilized in the neutral position (Fig. 5), if there is a tendency to

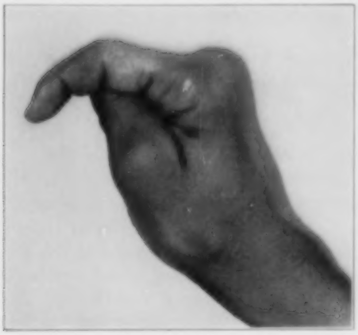

FIG. 6-A

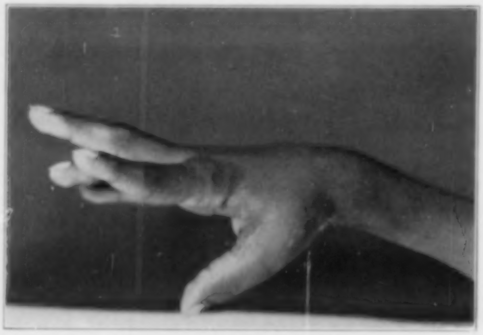

FIG. 6-B

Fig. 6-A: Preoperative photograph shows the thumb-in-palm deformity with flexion of the metacarpophalangeal joint of the thumb. There is also spasticity in the thumb web as a result of the action of the adductor pollicis and the first dorsal interosseus.

Fig. 6-B: The spasticity in the thumb web has been released and the metacarpophalangeal joint of the thumb has been arthrodesed. Following stabilization procedures on the thumb and the opening of the thumb web, the thumb stays out of the palm. The flexor carpi radialis and the flexor carpi ulnaris have been transferred to the weakened extensor digitorum communis. This allows full extension of the digits and improves the pinch and grasp.

Fig. 6-C: With the thumb out of the palm and with active extension of the digits, the patient now has grasp and pinch, and, although there is considerable incoordination when the hand is used, the operative procedures have enabled the hand to help in carrying out gross movements.

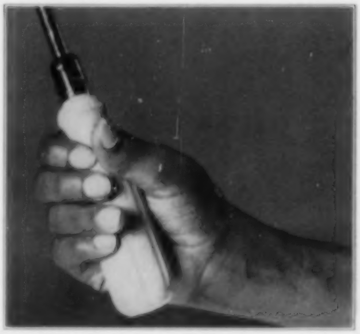

FIG. 6-C

flexion or extension deformity. A rigid thumb augments the tenodesis effect of the extensors which occurs with slight flexion or extension of the wrist. Because of the rigidity which follows a fusion of the carpometacarpal joint or a synostosis between the first and second metacarpals, these procedures have not been selected for this group of patients.

Spasticity and contracture of the thumb web (Fig. 6-A) have been treated by sectioning the web fascia, by stripping the first dorsal interosseus from the first metacarpal, and by tenotomizing the adductor pollicis [4]. These procedures are usually done in conjunction with a metacarpophalangeal-joint fusion (Fig. 6-B). The joint fusion and the release of soft tissue obviate the necessity for doing a neurectomy to the motor branch of the ulnar nerve. Thumb function is not weakened appreciably because of this surgery (Fig. 6-C). Correction of the contracture allows other muscle groups to become strengthened at the expense of those which are tenotomized.

An opponens transfer [2] may be beneficial if there is paralysis or weakness of the opponens pollicis and other intrinsic muscles of the thumb, as well as spasticity of the finger flexors (Fig. 7-A). This transfer can be done in conjunction with fusion of the metacarpophalangeal joint of the thumb. The most satisfactory method of replacing opponens weakness [9] is by using the flexor digitorum sublimis of the long finger or the ring finger, even though it may be spastic (Fig. 7-B). Cutting the tendon removes an overactive finger flexor and partially eliminates the finger-in-palm deformity, if it is present. Restoration of thumb movement will be of little value if the other digits are not able to function.

See Table I for summary of procedures performed about the thumb.

### *Deformities of the Fingers*

Spastic finger flexors (Fig. 8) may cause the digits to be held tightly in the palm.

TABLE I

RESULTS OF OPERATIONS FOR DEFORMITIES OF THE THUMB

| Deformity | No. of Patients | Surgical Procedure | Duration of Follow-up (*Years*) | Functional Result |
|---|---|---|---|---|
| 1. Hypermobile metacarpophalangeal joint | 9 | Arthrodesis of metacarpophalangeal joint | 3 | Improvement of grasp, pinch, and stability of thumb enabling hand to aid in tying shoes, eating, and handling large objects.<br>Improvement of function of other digits, since thumb remains out of palm. |
| 2. Loss of opponens power (from injury to cervical cord) | 2 | Opponens transfer | 3 | Improvement of pinch, grasp, and thumb stability. Ability to pick up small pieces of paper and write with this hand. |
| 3. Contracture of thumb web | 2 | Section of adductor pollicis and flexor pollicis brevis.<br>Fascia was cut and the first dorsal interosseus was stripped. | 3 | Thumb remains out of the palm.<br>Better stability and diminished spasticity. Ability to grasp and release. |

particularly if the wrist is tight in dorsiflexion. This position increases the flexion of the fingers by the tenodesis effect on the finger flexors [15]. The flexion of the fingers will be severe if the extensor and intrinsic muscles are stretched or paralyzed. When the finger flexors are strong and the extensors weak, a large object can be grasped with the fingers, if the wrist is flexed. As the grasp is tightened, the hand automatically dorsiflexes because of the increased tension on the extensor mechanism. Once the hand reaches the neutral or straight position, release is nullified because there is diminished tension on the extensor tendons and increased tension on the flexors. In such cases, it is desirable to diminish the spasticity in the flexors of the fingers and to increase the strength of the extensors of the wrist and of the fingers. Several procedures are available for reaching this goal.

### *Operations to Improve the Function of the Fingers*

1. Plaster-stretching for six or eight weeks may lengthen the flexors and may determine whether or not there is active motor power in the extensors. If the extensors are inadequate, an overactive wrist flexor such as the flexor carpi ulnaris may be transplanted to the extensor digitorum communis of the long, ring, and little fingers, just as is done for palsy of the radial nerve [5, 10, 13, 16]. At the same time, the sublimis of the long or ring fingers may be transferred to the extensor of the index finger. All of the flexores digitorum sublimes may be removed if the flexores digitorum profundi are functioning. This procedure is done in preference to partial neurectomy of the median nerve, tenotomy of the flexores digitorum sublimes, or release of their muscle bellies.

2. Even after the flexores digitorum sublimes have been removed, a severe flexion deformity of the proximal interphalangeal joints may persist. Paralysis of the intrinsic muscles of the hand along with fixed changes in the extensor mechanism aggravate this condition. In such cases, arthrodesis of the interphalangeal joints with shortening of the fingers is justified. This arthrodesis, by eliminating one joint, brings the fingers out of the palm, adds stability to the digits, and reduces the possibility of recurrent deformity. This procedure, however, is rarely indicated.

3. The muscle balance may be such that the distal interphalangeal joints cannot

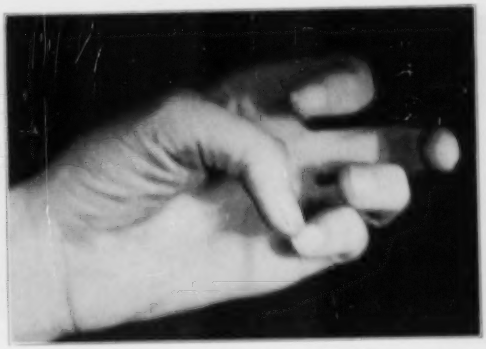

FIG. 7-A

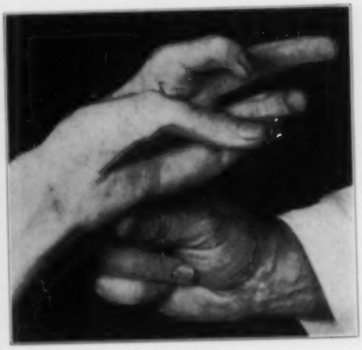

FIG. 7-B

Fig. 7-A: Preoperative photograph shows opponens weakness. Spasticity of the hand resulting from an injury to the cervical cord is seen in conjunction with motor weakness of specific groups as a result of the same injury. The thumb can be apposed to the little finger but cannot be elevated and rotated because of weakness of the intrinsic muscles. Notice the flexion deformity of the index finger as a result of paralysis of the interossei and the lumbrical to this digit.

Fig. 7-B: Postoperative photograph. In spite of the spasticity, the flexor digitorum sublimis of the ring finger has been transferred to the proximal phalanx of the thumb in order to substitute for the weak intrinsic muscles. Adequate elevation and opposition are now present. The index finger has also been strengthened by a "split-sublimis" transfer from the long finger in order to substitute for the intrinsic-muscle weakness. Fusion of the metacarpophalangeal joint of the thumb was not done because the joint was stable.

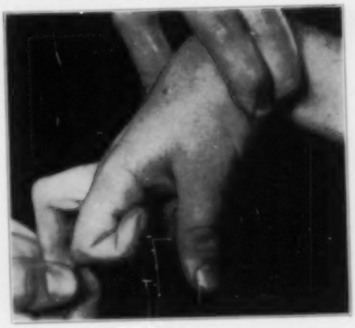

FIG. 8

Fig. 8: Spasticity of the finger flexors may prevent extension of the digits, even if there is power in the extensors. If the patient has some control of the hand and if, with the wrist in the neutral position, the digits can be passively straightened, then it is desirable to correct the flexion contractures in order to augment extension of these digits.

be flexed because of weakness or paralysis of the flexores digitorum profundi (Fig. 9-A). The sublimis muscle may be strong enough for flexion of the proximal interphalangeal joints. If, when pinch is attempted, the distal phalanges hyperextend, stability and strength at the distal joints may be obtained by suture of the weak profundus tendons

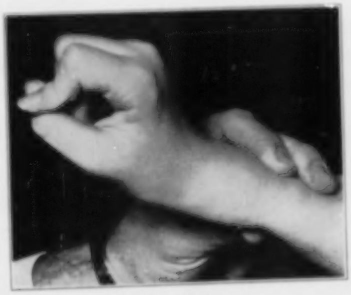

FIG. 9-A

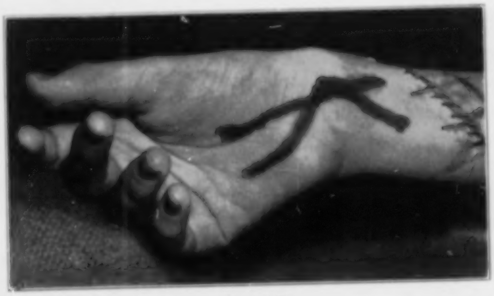

FIG. 9-B

Fig. 9-A: Extension deformity of the hand at the wrist with hypermobile interphalangeal joints and weakness of finger-tip flexion. If the distal interphalangeal joint cannot be stabilized, then the grasp and pinch continue to be weak.

Fig. 9-B: In order to augment the weak flexores digitorum profundi, they were "tapped" into the flexores digitorum sublimes, thereby shortening the profundi and allowing the active motor to work on the finger tips. This procedure gave a moderate amount of increased stability in the finger tips. Arthrodesis of the distal interphalangeal joints is not yet necessary in this particular hand.

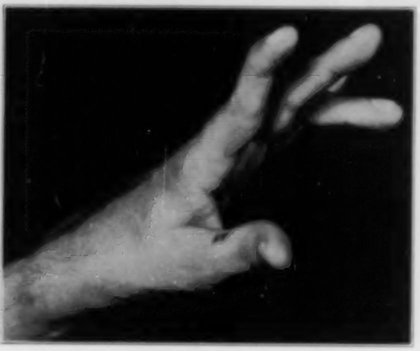

FIG. 10-A

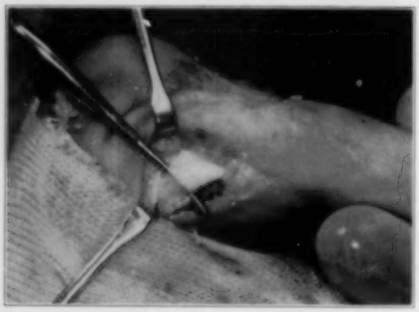

FIG. 10-B

Fig. 10-A: Notice the "intrinsic-plus" deformity of the index finger. This hand has already had a transfer of the wrist flexors to the finger extensors followed by arthrodesis of the wrist in the neutral position. The deformity of the index finger has occurred slowly, as a result of the tendon transfer and contracture of the intrinsic muscles. In order to augment flexion in this digit, release of the tension at the proximal interphalangeal joint must be accomplished. (This photograph is a postoperative view of the hand shown in Fig. 12-C.)

Fig. 10-B: The lateral band on the radial aspect of the index finger has been isolated just distal to the metacarpophalangeal joint. After the lateral band is sectioned on the radial and ulnar side of the phalanx, the proximal interphalangeal joint can be flexed actively. The profundus tendon to this digit was supplemented by an additional motor.

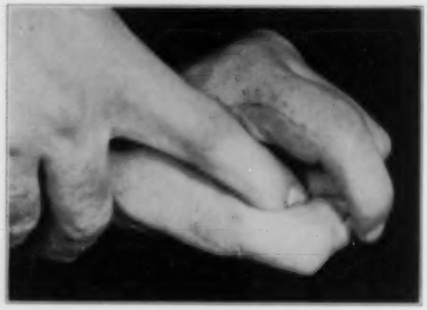

FIG. 10-C

Fig. 10-C: Postoperative function of the index finger following section of the lateral bands. There is voluntary flexion and pinch is improved.

to the strong sublimis tendons at the wrist (Fig. 9-B). If, by this procedure, the motor power in the finger tips is not improved, arthrodesis of the distal joints may be done.

4. The index or "pinch" finger (Fig. 10-A) may present the problem of hyperextension of the proximal interphalangeal joint with flexion of the distal joint. This malfunction may be the result of spastic intrinsic muscles or overaction of a transferred flexor into an extensor. Weakness of the flexor digitorum profundus of the index finger prevents strong flexion of the digit. In order to correct the hyperextension deformity of the proximal interphalangeal joint, the lateral and connecting bands (Fig. 10-B) may be sectioned along the shaft of the proximal phalanx[3, 8]. At the same time, the motor power of the profundus can be augmented by transplantation of a muscle, such as the sublimis or the palmaris longus (Fig. 10-C).

5. The opposite deformity, the "claw" index finger, results if the lumbricals and interossei are paralyzed (Fig. 11-A). In this case, the pinch is weak, extension of the proximal and distal interphalangeal joints is difficult, and there is weakness when stabilization of the metacarpophalangeal joint is attempted in flexion. Transfer of the split sublimis has proved satisfactory for this isolated weakness of the index finger[6] (Fig. 11-B).

The sublimis tendon from the ring or little finger is isolated at the proximal crease of the finger. The curved incision is then made on the radial aspect of the wrist joint and the flexor digitorum sublimis tendon to be used is isolated. The tendon is then severed in the digit and pulled out through the wrist incision. The tendon is split lengthwise by separation of fibers as far as the muscle belly. One segment of the tendon is inserted subcutaneously over the dorsum of the second metacarpal to an incision made over the insertion of the dorsal and volar interosseous muscles. The second segment of the tendon

TABLE II

RESULTS OF TENOTOMY AND TENDON TRANSFER

| Deformity | No. of Patients | Surgical Procedure | Duration of Follow-up (*Years*) | Functional Result |
|---|---|---|---|---|
| 1. Flexion deformity of the wrist. | 5 | Transfer of flexor carpi ulnaris to finger extensors.<br>(This was first stage, followed by wrist arthrodesis in four patients.) | 3 | Ability to open and close the fingers, to handle a plow, and to drive a car. |
| 2. Thumb adduction.<br>External rotation or weakness of extension. | 9 | Re-routing of extensor pollicis longus.<br>Division of extensor tendon and reinforcement with flexor carpi radialis. | 3 | Ability to tie shoes, write, handle hammer, dress, grasp large and small objects, and an aid in eating. |
| 3. Extension deformity of index finger. | 1 | Tenotomy of lateral bands. | 3 | Ability to flex the proximal interphalangeal joint.<br>Improvement of pinch.<br>Index finger remains out of the way. |
| 4. Severe flexion deformity of fingers. | 2 | Transfer of flexor digitorum sublimis of fingers to extensor tendons of fingers and thumb. | 3 | Diminution of flexion deformity and ability to extend fingers.<br>Improvement of wrist extension.<br>Ability to grasp and release voluntarily. |
| 5. Inability to flex distal interphalangeal joints. | 1 | Transfer of flexor digitorum profundus to flexor sublimis at wrist. | 3 | Ability to control the finger tips, increase of grasp, elimination of hyperextension. |
| 6. Extension deformity of wrist with inability to extend fingers. | 1 | Transfer of extensor carpi radialis longus to extensor digitorum communis and re-routing of thumb extensor. | 2½ | Ability to flex wrist, extend fingers, hold a glass, and wash dishes.<br>Dressing, eating, and driving aided. |

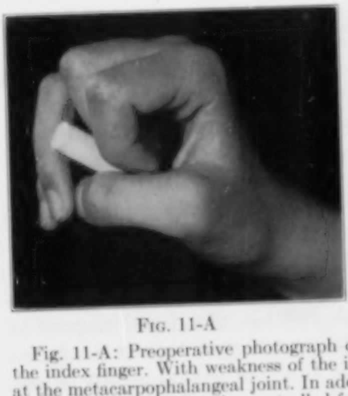

FIG. 11-A

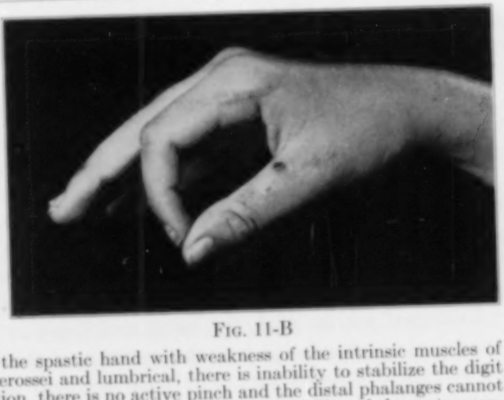

FIG. 11-B

Fig. 11-A: Preoperative photograph of the spastic hand with weakness of the intrinsic muscles of the index finger. With weakness of the interossei and lumbrical, there is inability to stabilize the digit at the metacarpophalangeal joint. In addition, there is no active pinch and the distal phalanges cannot be extended and cannot be controlled for pinch. Notice that there is hypermobility of the metacarpophalangeal joint of the thumb and that the thumb has a tendency to stay flexed in the palm.

Fig. 11-B: The postoperative photograph shows that the flexor digitorum sublimis of the ring finger has been isolated, removed from the digit, split, and re-routed. One portion of the tendon has been attached to the interosseous tendon on the dorsum of the finger; the other portion of the tendon has been attached to the lumbrical insertion through the lateral band on the volar aspect. Surgical arthrodesis of the metacarpophalangeal joint had been performed in the thumb. The hand after eighteen months' observation shows a good grasp and pinch, and the child can now pick up pins and write with a pencil.

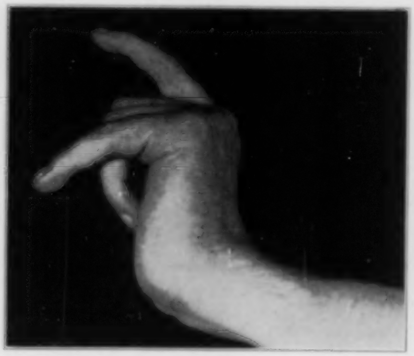

FIG. 12-A

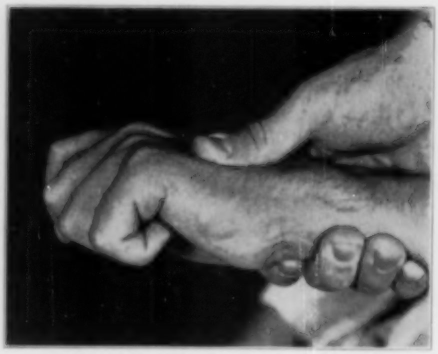

FIG. 12-B

Fig. 12-A: This hand originally was in severe flexion at the wrist with the fingers in the palm. There was complete paralysis of the extensor muscles. The tendons of the flexor carpi radialis and the flexor carpi ulnaris have been sutured to the finger extensors. Within six weeks following removal of the cast, dorsiflexion deformity of the hand occurred. The index finger hyperextended and gradually the "intrinsic-plus" deformity developed. The possibility that these deformities will develop several weeks after the tendon surgery is the primary reason why the tendon transfer should precede arthrodesis of the wrist.

Fig. 12-B: With the hand held in the neutral position, the finger flexors can function, although there is a lag in flexion of the index finger.

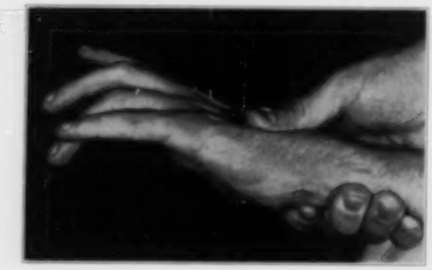

FIG. 12-C

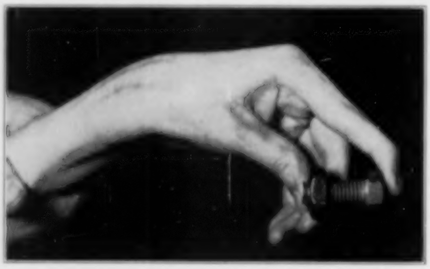

FIG. 13

Fig. 12-C: With the hand stabilized in the neutral position and with the transplanted wrist flexors functioning through the finger extensors, the digits can be actively extended. If the wrist is arthrodesed in excessive dorsiflexion, the patient will not be able to extend the digits.

Fig. 13: If there is considerable weakness in the hand and active motors are not available for strengthening the paralyzed muscles, it may be necessary to do an arthrodesis of the wrist which includes only the radius and the carpal bones, the carpometacarpal joints being left to allow limited motion in the wrist. This allows the fingers to extend and to flex moderately. The arthrodesis of the metacarpophalangeal joint of the thumb keeps the thumb out of the palm.

is passed through the lumbrical canal of the index finger by means of a retrograde probe. The lateral band of the index finger is identified. The hand is placed in 30 degrees of flexion at the wrist, the metacarpophalangeal joint of the index finger is flexed approximately 60 degrees, and the finger is held over in radial deviation with full extension at the interphalangeal joints. With the hand and finger in this position, the dorsal segment of the sublimis is button-holed into the insertion of the interosseous muscles and is sutured with interrupted braided wire. The volar segment of the sublimis tendon is laid on the radial lateral band of the index finger and is sutured with interrupted fine braided wire. An aluminum finger splint held by a forearm plaster cast is used for immobilization. After three weeks, active motion is allowed.

6. The problem of excessive mobility of the interphalangeal joints is not readily solved. Relaxation of the joints may be inherent in the makeup of the hand. The flexed position of the wrist along with increased tension of the extensor mechanism, as well

as active function of the intrinsic muscles, increases the hypermobility of the interphalangeal joints. In most instances, arthrodesis, rather than tendon transfer, is required if the hypermobility interferes with the function of the hand.

See Table II for operations on the fingers.

### *Wrist Deformities*

A wrist-flexion deformity which is the result of spasticity of the flexors of the wrist and fingers may be difficult to control. A preliminary period of stretching by means of a cast or brace may be tried in an effort to determine the strength of the extensor muscles. If the motor power of the extensors is weak and active flexion of the fingers is present, a reconstructive procedure should be considered.

### *Operations for Wrist Deformities*

Arthrodesis of the wrist is the basic procedure used to control severe flexion deformity. The decision to do an arthrodesis will depend upon the ability of the patient to perform grasp and release when the wrist is stabilized in the optimum position, either by a cast or by a splint. If active extension cannot be done because of paralysis of the extensors, the wrist flexors should be transferred to the finger and thumb extensors. An extension deformity (Fig. 12-A) may develop following the transfer of tendons, and for this reason the tendon surgery should be done several months prior to the contemplated fusion of the wrist. The optimum position for arthrodesis of the wrist will be determined during the intervening period. The position of dorsiflexion of 20 or 25 degrees for arthrodesis advocated in textbooks is not always satisfactory. In this position, the tension on the finger flexors is increased, and the finger-in-palm, as well as the thumb-in-palm, deformities are exaggerated. Furthermore, active extension of the digits is more difficult with the hand in even slight dorsiflexion. The neutral position of 180 degrees has been satisfactory for certain hands. Other hands have functioned best with the wrist arthrodesed in 5 to 10 degrees of flexion (Figs. 12-B and 12-C) because, in this position, grasp and release are done with the least amount of effort. The decision to place the hand in ulnar deviation at the time of the arthrodesis depends upon the function of the thumb. If the tendon transfers begin to function, a stabilizing plaster cast or an adjustable splint should be used to determine the optimum position for arthrodesis. In the strong spastic hand, fusion includes the radius, the carpals, and the second and third metacarpals. The ulnar-carpal and the distal radio-ulnar joints are left intact, in order to maintain pronation and supination.

In the hands which depend on wrist motion for automatic opening and closing of the digits or in those in which the extensors are weak and, because of the paucity of motors, cannot be strengthened, arthrodesis is carried out between the radius and the carpal bones. Leaving the carpometacarpal joints without arthrodesis allows several degrees of flexion and extension. This limited motion at the wrist may be the only means available for initiating the minimal grasp and release necessary to make the hand even slightly useful (Fig. 13). Wrist arthrodesis is not indicated when active flexion and extension of the wrist and fingers allow satisfactory grasp and release. Wrist stabilization will not increase function if the digits are extremely weak. Arthrodesis for cosmetic purposes is justified in the hemiplegic patient when the flexed wrist is a psychological deterrent to rehabilitation.

Extension deformity of the wrist is less common than the flexion deformity of the wrist. If the wrist extensors are strong and the finger extensors are weak, the wrist extensors can be transferred and sutured to the finger extensors; the strengthened extensors allow release of the grasp by initiating extension of the digits. In order to aid gravity in partially flexing the wrist it may be necessary to transfer an active wrist extensor to a paralyzed wrist flexor, thereby increasing the tenodesis effect on the digits. If fixed changes

TABLE III

RESULTS OF ARTHRODESIS OF THE WRIST AND OF THE FINGER JOINTS

| Deformity | No. of Patients | Surgical Procedure | Duration of Follow-up (*Years*) | Functional Result |
|---|---|---|---|---|
| 1. Reversal of original flexion deformity of wrist to extension deformity of wrist, following tendon transfer. | 3 | Arthrodesis of wrist joint in neutral position. | 3 | Ability to drive a car with this hand, hold a plow, use a broom, aid in dressing, eating, working.<br>Good stability, pinch, and strength. |
| 2. Flexion deformity of wrist with weak flexion and extension of fingers. | 1 | Arthrodesis of radius to proximal row of carpal bones in order to maintain moderate range of flexion and extension. | 3 | Moderate improvement in opening and closing fingers. Ability to pinch a small object and to pluck an electric guitar. |
| 3. Severe flexion deformity of wrist, no finger extension or flexion. | 1 | Arthrodesis of wrist joint for cosmetic reasons (female, aged nineteen). | 3 | No functional improvement in the hand but psychological improvement so that patient was able to secure employment in public. |
| 4. Extension deformity of proximal interphalangeal joint. | 1 | Arthrodesis of proximal interphalangeal joint. | 3 | Improved pinch, and grasp for large objects. |
| 5. Extension deformity of distal interphalangeal joint. | 2 | Arthrodesis of distal interphalangeal joint. | 3 | Prevention of extension of finger tips when grasping.<br>Improved stability, strength, and handling of small objects. |

occur as a result of the transfers, joint stabilizations may be required to supplement the tendon transfers.

See Table III for operations on the wrist joint.

### *Other Factors*

The minimum age of the patient for whom these surgical procedures are advocated will vary according to the procedure and the intelligence of the child. Arthrodesis of the thumb joint may be done on patients as young as six years of age, care being taken not to damage the epiphysis of the proximal phalanx. Tendon transfers of flexors into extensors can be considered for patients in the general age group of seven or older. Wrist arthrodesis is delayed until age twelve or thirteen. The soft-tissue procedures about the thumb web could be done at age six after a preliminary period of stretching.

Certain patients in the group have developed new hand deformities following specific tendon transfers. In two hands, hyperextension of the proximal interphalangeal joint of the index finger occurred following transfer of the wrist flexors to the finger extensors. This was corrected by tenotomy of the lateral bands in one instance and arthrodesis of the proximal interphalangeal joint in a second. In two hands, dorsiflexion contracture at the wrist occurred following the transfer of the wrist flexors to the finger extensors which had been done for correction of a severe volar-flexion contracture. Active extension of the fingers resulted and wrist arthrodesis was done in the neutral position. In one hand, a flexion deformity of the thumb gradually changed to a hyperextension deformity at the metacarpophalangeal joint following transfer of the flexor carpi radialis tendon to that of the extensor pollicis longus. This was corrected by arthrodesis of the metacarpophalangeal joint in the neutral position. The appearance of a deformity which is the reverse of the original deformity should be expected in certain cases, and for this reason the tendon transfers are done initially and the joint arthrodesis is delayed for several months, depending on the outcome of the tendon transfer.

## SUMMARY

1. In cerebral-palsy patients, the majority of deformities about the hand cannot be aided by surgery. The prognosis is somewhat better for surgical procedures in those patients who have had an injury of the cervical cord with resulting spasticity of the hands. Spastic hands which are reasonably good from the outset can be improved by stretching, splinting, and re-education; those which lack a major muscle group or which have a specific deformity may, in some instances, be aided by surgery. The operative procedures are selective. Preliminary observation and study are essential. The end result is never a cure, but only an improvement in the ability to learn specific functions. Even though the better hand, or normal hand if present, will be used for most activities, the surgical procedures can give the patient a "helping hand", which will increase his independence.

2. Selective tenotomies and tendon transfers can improve function of the hand in certain patients with cerebral palsy or with spasticity resulting from trauma to the cervical cord. However, even with a carefully chosen and well executed program, failures will occur.

3. Tendon surgery, if indicated, is done as the initial procedure and is followed when necessary by joint arthrodesis. Arthrodesis of the metacarpophalangeal joint of the thumb is a useful procedure. The position of the wrist for arthrodesis should be determined carefully prior to the definitive operation. Neurectomies of the forearm or hand musculature have not been done in this group of patients.

## REFERENCES

1. Baker, L. D.: Personal communication.
2. Bunnell, Sterling: Surgery of the Hand. Ed. 2. Philadelphia, J. B. Lippincott Co., 1948.
3. Bunnell, Sterling; Doherty, E. W.; and Curtis, R. N.: Intrinsic Contracture, Local of the Hand. J. Plast. and Reconstruct. Surg., **3:** 424–432, 1948.
4. Burman, M. S.: The Spastic Hand. J. Bone and Joint Surg., **20:** 133–145, Jan. 1938.
5. Chandler, F. A.: Surgical Treatment of Spastic Paralysis. N. Y. State Med. J., **39:** 338–344, 1939.
6. Coonrad, R.; Eyler, D.; and Irwin, C. E.: Split Sublimis Transfer for Paralysis of the Intrinsic Muscles of the Index Finger. Correspondence Club Letter, Duke-Georgia Warm Springs Training Program, 1951.
7. Cooper, William: Surgery of the Upper Extremity in Spastic Paralysis. Quart. Rev. Pediat., **7:** 64, 1951.
8. Goldner, J. L.: Deformities of the Hand Incidental to Pathological Changes of the Extensor and Intrinsic Muscle Mechanisms. J. Bone and Joint Surg., **35-A:** 115–131, Jan. 1953.
9. Goldner, J. L., and Irwin, C. E.: An Analysis of Paralytic Thumb Deformities. J. Bone and Joint Surg., **32-A:** 627–639, July 1950.
10. Green, W. T., and McDermott, L. J.: Operative Treatment of Cerebral Palsy of Spastic Type. J. Am. Med. Assn., **118:** 434–440, 1942.
11. Heyman, C. H.: Surgical Treatment of Spastic Paralysis. Surg., Gynec., and Obstet., **68:** 792–800, 1939.
12. Littler, J. W.: Tendon Transfers and Arthrodeses in Combined Median and Ulnar Nerve Paralysis. J. Bone and Joint Surg., **31-A:** 225–234, Apr. 1949.
13. McCarroll, H. R.: Surgical Treatment of Spastic Paralysis. *In* Instructional Course Lectures of The American Academy of Orthopaedic Surgeons, 1949. Vol. 6, pp. 138–139. Ann Arbor, J. W. Edwards, 1949.
14. Phelps, Winthrop: Personal communication.
15. Steindler, A.: Operations on the Upper Extremities: Problems in Kinetics; End Results. J. Bone and Joint Surg., **9:** 404–411, July 1927.
16. Thibodeau, A. A.; Wagner, L. C.; and Carr, F. J., Jr.: The Evaluation of Surgical Procedures on Bones, Muscles, and Peripheral Nerves in Spastic Paralysis. Am. J. Surg., **43:** 822–848, 1939.

## DISCUSSION

Dr. H. Relton McCarroll, St. Louis, Missouri: I would like to repeat and reemphasize Dr. Goldner's opening statement that surgical procedures are seldom indicated in the hand of an individual with spastic paralysis. In his series of 800 patients, only 300 were considered eligible for treatment of any type, and only twelve of that group were considered eligible for surgical reconstructive measures. It is safe to state, therefore, that surgical procedures are so seldom indicated that the average surgeon will not find use for them very often.

In the past, we have considered three surgical procedures justified in the hands and wrists of these patients. The first is arthrodesis of the wrist for improvement of the function of the digits and for the correction of deformity. The second is fixation of the thumb in order to correct the fixed adduction deformity which is occasionally encountered. Transplantation of the flexors of the wrist into the finger extensors, the third procedure, is used in an occasional case only when it is necessary to enable the patient to release his grip after the fixation of his wrist has made it possible for him to make a fist. If the individual is able to extend his fingers just sufficiently to release his grip, transference of tendons is not indicated. He does not have to be able to completely extend his fingers, but he must be able to release the grip just enough to release an object as he wishes.

In addition to these procedures, Dr. Goldner has described several more detailed procedures which may be considered justifiable in the treatment for these patients. Whether or not they are justified may, I think, be open to question. We do not often see fine function after transplantation of tendons in the hands of the spastic child or the spastic individual. In the majority of our cases, the improvement has come from correction of the deformity rather than from change in specific function itself. Dr. Goldner has shown, however, some very satisfactory results. These results may certainly be considered satisfactory, especially from the standpoint of the type of individual with which he was dealing. It is possible, therefore, that we should stop occasionally to take stock of our position in this problem and perhaps to alter our opinion somewhat with reference to these various measures.

I think it is safe to state, however, and to repeat again that these procedures are not very often justified or indicated. We must remember that reconstructive measures of this type cannot be used in the hand of the patient with spastic paralysis in the same way in which they are applied to patients with poliomyelitis or injuries to the peripheral nerves. If we attempt to apply and to use them in the same way, the patient and the surgeon in the majority of instances will certainly be subjected to a great deal of disappointment.

DR. WILLIAM COOPER, NEW YORK, N. Y.: I have found Dr. Goldner's analysis of this problem very stimulating but in some respects rather theoretical. I do agree with many of the principles he sets down, but must regard his surgical recommendations with some reservation. Our experience on the Cerebral Palsy Service at the Hospital for Special Surgery has led us to somewhat different conclusions. Transplantation of spastic muscles has proved remarkably unreliable, and in spite of occasional outstanding results, we have not been encouraged in its use. This disinclination would apply particularly to some of the more involved types of transplantation that Dr. Goldner has illustrated. In cerebral palsy we have felt more and more that only procedures with the most elementary objectives yield consistently good results. In general, our surgery for cerebral palsy is largely confined to arthrodesis, tenotomy, and neurectomy. In the hand, arthrodesis of the wrist has proved more valuable than all of the other procedures combined. Dr. Goldner's present thesis is based on a small number of patients. I wonder whether his future experience will not lead him to a similar conclusion.

Certain elementary considerations govern the function of the spastic hand and should determine the objectives of therapy:

1. The position of the thumb, which Dr. Goldner emphasizes, also has a profound effect on the function of the other fingers, which he fails to mention. With the thumb adducted into the palm, as it usually is in spastic paralysis, active extension of the fingers may be difficult or impossible. When the thumb is even passively abducted, the other fingers may spontaneously extend. This is the first objective: *Get the thumb out of the palm, so that the hand can be opened.*

2. When the wrist is in flexion, as it usually is in spastic paralysis, the fingers cannot be flexed completely, and only partial grasp is possible at best. If the wrist is extended, even passively, the fingers can usually be flexed into the palm. This is the second objective: *Get the wrist up, so that the hand can be closed.*

To accomplish the first objective, abduction of the thumb, we have placed the hand in considerable ulnar deviation, so that the thumb is passively withdrawn from the palm. This has proved more useful than other measures. The techniques suggested by Dr. Goldner are employed rarely, and only if this one fails.

Our practice is to maintain the wrist in extension and ulnar deviation. A cast or splint is first used as a test. If function is improved, arthrodesis of the wrist in the same position is carried out.

We have been concerned, as Dr. Goldner has, with the flexed position of the fingers which is so prominent when the wrist is extended. These contractures are usually not permanent or fixed, even though they appear to be so. We have never found an occasion for arthrodesis of the interphalangeal joints or for tenotomy of all of the tendons of the flexor digitorum sublimis, as Dr. Goldner has. After successful fusion of the wrist, gradual improvement in active extension of the fingers ordinarily develops without any assistance from splints, stretching, or surgery. There is a latent capacity in the spastic hand which we generally underestimate.

*(Continued on page 1205)*

# PROGNOSIS AND TREATMENT OF DUPUYTREN'S CONTRACTURE*

BY DR. RAOUL TUBIANA, PARIS, FRANCE

*From the Clinique de Chirurgie Orthopédique et Réparatrice de la Faculté de Paris* †

It is currently admitted that the prognosis for Dupuytren's contracture is unpredictable, since it is influenced by certain factors which are still obscure. We propose to analyze these factors, in order to establish a more effective treatment for this condition.

In order to clarify this report and to evaluate the lesions, we have adopted Meyerding's classification of five stages of contracture[11], as modified by Einarsson, which follows:

"Grade 0: Nodules in the palmar aponeurosis, sometimes involving the skin, but no flexion deformity.

"Grade I: In addition to the conditions already mentioned, major or minor flexion deformity of one finger only.

"Grade II: Flexion deformity of more than one finger, nowhere attaining 60 degrees.

"Grade III: Flexion deformity of more than one finger, exceeding 60 degrees in at least one.

"Grade IV: Major or minor flexion deformity of all fingers."

This classification is not exempt from criticism but has the merit of having been used by numerous authors.

We have classified the postoperative results as follows:

*Very good:* Hands normal, both in appearance and in function;

*Good:* Hands in which a mild deformity persists, but which show much improvement as compared with their previous state;

*Fair:* Hands in which the improvement is less marked;

*Poor:* Hands in which there is either no improvement or deterioration.

## STUDY OF THE ETIOLOGICAL ELEMENTS IN THE PROGNOSIS

This study of etiological factors, based on 100 cases of Dupuytren's contracture followed at the *Clinique de Chirurgie Orthopédique et Réparatrice de la Faculté de Paris*, has given us only limited information on the prognosis.

The hereditary tendency of this condition was found in about 15 per cent. of our cases. This tendency does not seem to influence unfavorably the operative results, except in certain cases of extreme atypical deformity, often localized in one finger, which can be found in members of the same family; the operative prognosis appears to depend principally on the degree of flexion.

Manual work does not seem to influence the incidence or the degree of deformity or the operative results, but the bilaterality of the lesions is noted much more frequently in manual workers,—in sixteen of twenty-five cases, as compared with non-manual workers, of whom six of thirty-five were affected bilaterally.

We have systematically inquired about previous injury and have found that in about one-third of our patients, fractures, wounds of the hand, of the forearm, or of the shoulder had preceded the palmar thickening. Dupuytren's contracture occurred bilaterally in eighteen patients; in only four of these patients (eight hands) the lesion occurred after bilateral traumatic injuries. In fourteen patients, it occurred unilaterally and always on the side of the injury. Neither the severity of the lesions nor the operative results were influenced by these previous injuries.

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* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 24, 1953. Manuscript received for publication May 25, 1954.

† Service of Prof. R. Merle d'Aubigné.

TABLE I

INFLUENCE OF AGE ON CERVICAL ARTHRITIS AND DUPUYTREN'S CONTRACTURE

| Ages | Total No. of Cases in Each Series | Patients with Dupuytren's Contracture X-Rays Normal | Patients with Dupuytren's Contracture X-Rays Arthritis | Patients without Dupuytren's Contracture X-Rays Normal | Patients without Dupuytren's Contracture X-Rays Arthritis |
|---|---|---|---|---|---|
| 0–19 | 1 | 1 | 0 | 1 | 0 |
| 20–29 | 3 | 3 | 0 | 3 | 0 |
| 30–39 | 3 | 2 | 1 | 3 | 0 |
| 40–49 | 9 | 7 | 2 | 6 | 3 |
| 50–59 | 11 | 2 | 9 | 4 | 7 |
| 60–69 | 2 | 0 | 2 | 0 | 2 |
| 70–79 | 1 | 0 | 1 | 0 | 1 |
| Totals | 30 | 15 | 15 | 17 | 13 |

From our limited experience, we have not been able to establish whether the existence of associated lesions, such as knuckle pads or periarthritis of the shoulder, have any particular prognostic significance. They did not appear to have had any influence on the immediate postoperative results, but such a condition was observed in one of the four cases in which there was recurrence.

Padovani and Lord have drawn attention to cervical lesions in Dupuytren's contracture. We have made roentgenograms of the cervical spine in a series of thirty cases of Dupuytren's contracture; half of them showed arthritis at the level of the fifth and sixth cervical vertebrae. Roentgenograms made in a similar series of normal subjects of the same age showed a comparable incidence of arthritis (Table I).

Has the presence of cervical arthritis any influence on the prognosis of Dupuytren's contracture? With this question in mind, we have compared two series of patients, one group with and one without cervical arthritis. The influence of cervical arthritis on prognosis appears to be negligible. We have observed a greater frequency of bilaterality in patients with arthritis, but this finding seems scarcely to have influenced the degree or the development of the deformity or the operative sequelae of this condition.

It seems logical that the presence of trophic disturbances, such as cold hands, oedema, or hyperhidrosis, could influence the operative prognosis. We have only rarely encountered such conditions, and, in cases in which operation was carried out we have performed a stellate-ganglion block before and after operation.

We have operated on patients with the following conditions with satisfactory results: a patient who had Dupuytren's contracture associated with Raynaud's disease; a young woman in whom the contracture followed an acute shoulder-hand syndrome; and several other patients with less marked signs of sympathetic hyperactivity.

It also seems natural to suppose that advanced age may influence the operative prognosis, but the results, as shown in Table II, are less pronounced than might be expected. Indeed, the group of our patients between twenty and thirty years of age have had the least number of satisfactory results.

One etiological factor which seems to influence the results is epilepsy, but our experience with this condition is very limited*. The four epileptic patients whom we have observed had already been operated upon once, and they all showed marked sequelae. These patients had taken barbiturates for years and continued to take them after the

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* Since writing this article, seven additional cases of Dupuytren's contracture have been seen in epileptic patients; in five of these there was extensive involvement affecting the thumb as well as the other fingers on both hands; three patients had plantar nodules. All of these patients had received barbiturates.

TABLE II

Results of Aponeurectomy as Related to the Age and Grade

| Ages | No. of Hands | Classification as to Grade: Grade 0 | Grade I | Grade II | Grade III | Grade IV | Results: Very Good | Good | Fair | Poor |
|---|---|---|---|---|---|---|---|---|---|---|
| 0–9 | 0 | | | | | | | | | |
| 10–19 | 4 | | 1 | 2 | 1 | | 4 | | | |
| 20–29 | 4 | 1 | | | 1 | 2 | 1 | | 3 | |
| 30–39 | 19 | 2 | 2 | | 14 | 1 | 8 | 6 | 4 | 1 |
| 40–49 | 5 | | 1 | 2 | 2 | | 1 | 3 | 1 | |
| 50–59 | 11 | | 2 | 4 | 4 | 1 | 6 | 3 | 1 | 1 |
| 60–69 | 11 | 1 | 1 | 5 | 4 | | 4 | 5 | 2 | |
| 70–79 | 2 | | | 1 | 1 | | | 2 | | |
| Totals | 56 | 4 | 7 | 14 | 27 | 4 | 24 | 19 | 11 | 2 |

operation. It is possible that barbiturate intoxication is in part responsible for the development of Dupuytren's contracture in epileptics, as has already been suggested by Lund and Skoog; perhaps Dupuytren's contracture also occurs in patients with other conditions for which barbiturates are used, as in patients with angina pectoris or with painful shoulder syndromes. From these observations, it appears that barbiturate therapy should be discontinued, when feasible, in patients in whom palmar contracture is found.

## LOCAL ELEMENTS IN THE PROGNOSIS

The combined review of our cases with J. I. P. James of London, which was presented in Paris at the *Congrès Français de Chirurgie Orthopédique* in 1952, suggested that local factors are of considerable importance.

The extent of the lesions as a prognostic gauge can be appreciated from Table III, in which the end results are evaluated in relation to the grade of the contracture. The patients who were operated upon early, when the contracture was manifested by palmar nodules only (Grade 0), have all had excellent results.

This classification, first proposed by Meyerding and modified by Einarsson, provides only an incomplete prognostic measure, for it does not take into account trophic disturbances or the state of the skin. It is evident that, whatever the grade of contracture, there is a great difference between skin which has a good blood supply and a subcutaneous

TABLE III

Results of Aponeurectomy as Related to Grade

| Classification | No. of Hands | Results: Very Good (*No. of Hands*) | Very Good (*Per cent.*) | Good (*No. of Hands*) | Good (*Per cent.*) | Fair (*No. of Hands*) | Fair (*Per cent.*) | Poor (*No. of Hands*) | Poor (*Per cent.*) |
|---|---|---|---|---|---|---|---|---|---|
| Grade 0 | 4 | 4 | | | | | | | |
| Grade I | 7 | 5 | | 2 | | | | | |
| Grade II | 14 | 6 | | 6 | | 2 | | | |
| Grade III | 27 | 9 | | 9 | | 7 | | 2 | |
| Grade IV | 4 | | | 2 | | 2 | | | |
| Totals | 56 | 24 | 43 | 19 | 34 | 11 | 20 | 2 | 3 |

layer composed of cellular and fatty tissue, which can be easily mobilized over the deeper planes, and skin which is thickened, infiltrated with fibrous tissue, and adherent to the aponeurosis.

However, without minimizing the prognostic importance of the state of the skin, we now preserve almost the whole extent of the skin, and we find that it survives satisfactorily in the majority of these cases.

In addition, this classification does not sufficiently take into account the prognostic significance of the site of the deformity. When the fingers are flexed, a distinction must be made between the contracture located at the metacarpophalangeal joint and that of the interphalangeal joints. The lateral ligaments of the metacarpophalangeal joint are stretched over the projections of the metacarpal condyles in flexion; they cannot retract in this position. The cases of Dupuytren's contracture in which only these joints are bent recover an excellent mobility.

When the proximal interphalangeal joints are affected, alone or conjointly, the problem is much more difficult. The recovery of full extension is sometimes possible at this level; however, when the deformity is marked and of long-standing, extension often remains limited despite the removal of aponeurotic bands, because of the presence of capsular contractures. For this reason, it is advised that removal of the palmar fascia be done either before or at the time of the first signs of contraction of the proximal interphalangeal joints.

Deformities at the level of the distal interphalangeal joints also have a prognostic significance. These joints are infrequently affected and are generally held in flexion. In certain cases, particularly those involving the fifth finger, the distal interphalangeal joints are in the position of hyperextension; Iselin and Dieckmann interpret this as an indication of the development of the disease to a marked degree and of bad functional prognosis, since the hyperextension implies contraction of the interossei or of the dorsal aponeurosis leading to the extensor apparatus.

Roentgenographic study of the involved joints can also be of value in prognosis; in some cases, signs of degenerative arthritis are found, but we believe them to be rare.

Dupuytren's contracture localized in the fifth finger should be considered separately from the prognostic point of view. Desplas and Tostivint have already noted the tendency for recurrence; and, with J. I. P. James, we have noted the frequency of complications in this digit.

We have operated eight times on contractures in the fifth finger. Five patients had previously been operated upon; in two patients we operated because of recurrences and in three because of bad results immediately following the first operation. In the other three cases in which we had undertaken the treatment of this condition, there was a local relapse which led us, in one case, to perform an arthrodesis of the proximal interphalangeal joint in 40 degrees of flexion, and, in another case, to use a skin graft in order to cover the loss of cutaneous substance after the straightening of the finger (a limitation of 40 degrees of extension still remains). Only one patient has had a good end result.

The gravity of the prognosis for the type of deformity which affects the fifth finger can be explained by the special anatomy which is present; although the condition is confined to a single finger, there is often widespread involvement. The distal joint was affected in all of our patients, and in two there was hyperextension. The aponeurotic expansions had adhered to the tendons of the hypothenar muscles, to the transverse metacarpal ligament, and to the hypothenar aponeurosis. Lastly, the relatively small size of this finger makes the dissection more difficult.

## PROGNOSIS BASED ON HISTOLOGICAL STUDY OF THE LESIONS

Meyerding and his colleagues[13] believe that histological examination of the pathological tissue can assist in forecasting the end result. They assumed that "the cellular nature of the fascia [described] indicates the activity of the proliferative process". In cases in which the condition recurred postoperatively, they found the tissue to be relatively immature, but without evidence of increased inflammatory activity.

Histological study undertaken by Dr. Nezelof on our specimens has not, up to the present, given us any indication regarding prognosis, since each anatomical section discloses variable histological appearances.

## THERAPEUTIC INDICATIONS

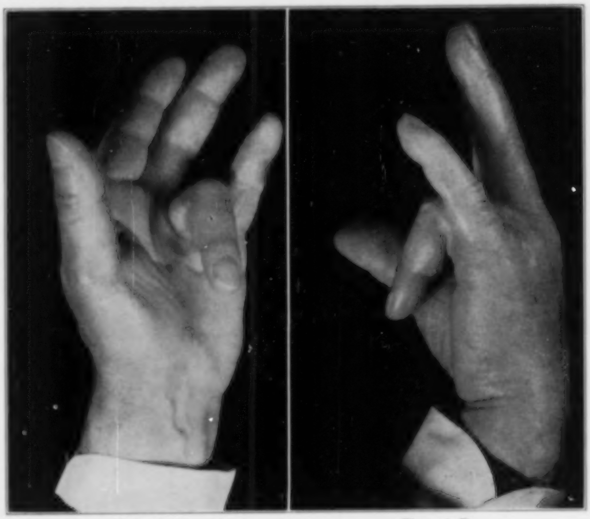
FIG. 1-A FIG. 1-B

Photographs showing retraction involving both metacarpophalangeal and interphalangeal joints.

Two factors seem to be of considerable importance in the prognosis: the choice and quality of treatment. Dupuytren's contracture is often only slightly troublesome until an advanced stage of its development, but the results of treatment are much better if surgery is performed early. However, when the condition is at the stage of isolated palmar nodules, we believe, as do the majority of those who have written on the subject, that it is preferable not to operate, since the lesions may remain stationary or may even partially regress spontaneously. When the condition shows a tendency to progress, especially when the interphalangeal joints

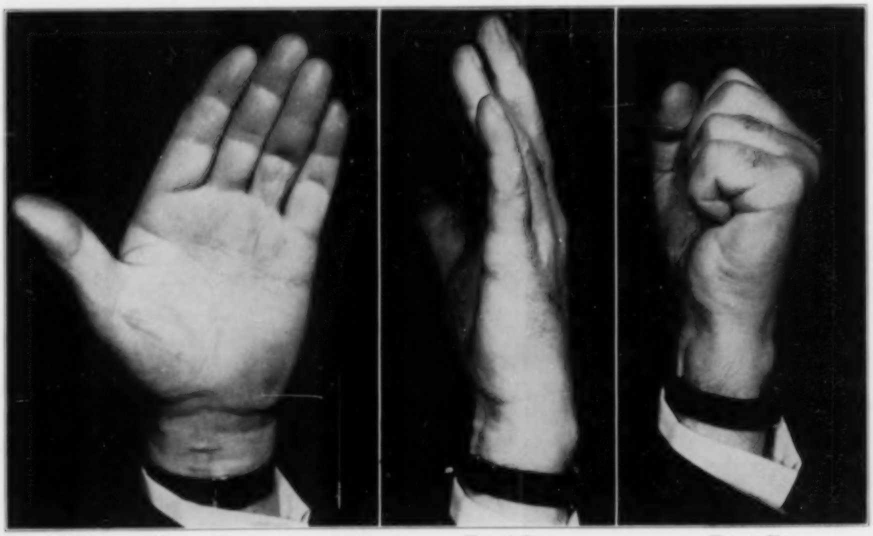
FIG. 1-C FIG. 1-D FIG. 1-E

Photographs showing results of operation.

are affected, it is our opinion that immediate surgery should be undertaken.

One may question whether the symptomatic treatment by local excision of the infiltrated fascia is sufficient; in the present state of our knowledge, once the condition has passed a certain stage, removal of the palmar fascia remains the sole effective treatment.

Are there contra-indications to surgery? Trophic or vasomotor disturbances and age constitute factors which influence the prognosis, but these are not necessarily absolute contra-indications to operation. In such cases, one must adopt a therapeutic procedure which avoids extensive surgery. If incomplete results satisfy the surgeon, limited operation may be employed. Local injection of hydrocortone is sometimes used for adjunctive treatment. Simple fasciotomy, in ambulatory patients, allows the fingers to extend from the palm, but one cannot hope to obtain results which are comparable in their quality and in their duration to those of fasciectomy, particularly when the deep aponeurotic septa are contracted. A blind operation becomes particularly hazardous at the level of the fingers, where the digital nerves are often displaced. Palmar fasciotomy has some value in elderly patients and, occasionally, in patients with very severe contractions in order to clean the hand in preparation for further surgery. It can also be a useful manoeuvre at the beginning of aponeurectomy to facilitate the dissection.

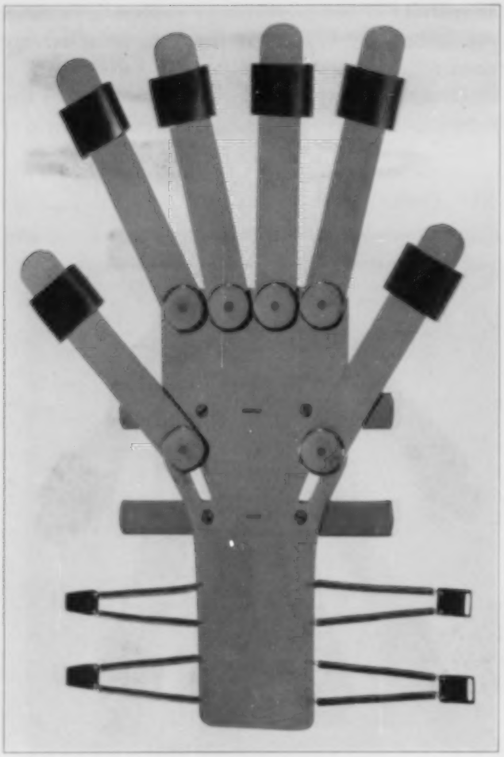

FIG. 2

Adjustable hand splint employed during the surgery.

The removal of the palmar fascia, including all the palmar and digital area involved, is the only procedure which gives a good percentage of excellent results. It is the operation of choice for the surgeon who has experience with this condition.

## TECHNIQUE OF APONEURECTOMY

Aponeurectomy is performed under a general anaesthetic and with a pneumatic tourniquet. The hand is fixed on an adaptable operative splint, such as the one which we have designed (Fig. 2).

The lines of incision must offer a wide exposure of the palmar and digital lesions, and the final scars must remain "physiological", as so appropriately expressed by Bunnell.

The standard approach to the palm is a transverse incision in a crease, usually the distal crease. Most of the time it is sufficient, without other débridement, to extend it from the second intermetacarpal space as far as the ulnar border. The elongation proximally along the hypothenar eminence or an incision in the thenar crease have been given up as unnecessary. At the level of the fingers, we use either a lateral longitudinal incision at the junction of the dorsal and palmar skin when the digital nodules are lateral or, like McIndoe, a vertical incision in the mid-line of each affected phalanx, which is made horizontal

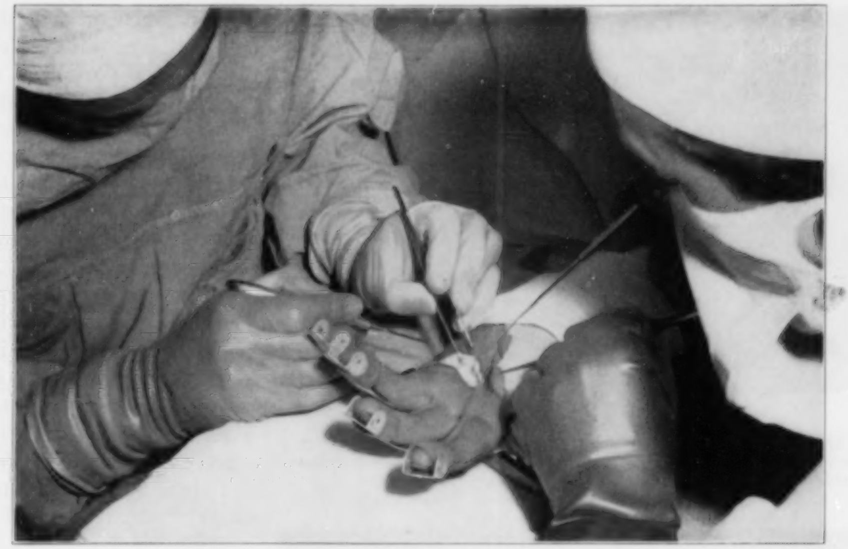

FIG. 3

Exposure of operative field by incision in the transverse palmar crease.

by using a Z plasty. This last process gives a wider exposure of the digital lesions and allows one to take advantage of the maximum amount of skin available.

An intact area remains between the palmar and digital incisions, and one may be tempted to simplify the dissection by using, like Iselin, a vertical incision on which as many Z plasties are made as there are segments.

This transposition of Z-flaps, pleasing as they are, may lead to sloughing at the angles when the skin is thick and devascularized; this sloughing may occur more frequently in the palm than on the fingers.

The extent of the aponeurectomy should be decided by the nature of the lesion and the general conditions. Our excision usually includes the three medial palmar spaces and the involved fingers. It is more limited in older patients and those with trophic disturbances. Since Dupuytren's contracture rarely affects the index finger and thumb, the palmar fascia to these two rays has not usually been removed. To do so would considerably extend the operation.

The procedure is as follows:

After the incision at the distal palmar crease, the skin is separated by meticulous dissection from the fascia, first in the proximal part of the palm. This is made easier by starting in the normal tissue at the side and working centrally toward the adherent skin. Then, after the edges of the upper part of this triangular fascia have been freed, the aponeurosis is elevated by traction forceps. At this level, there are no deep septa and a smooth spatula can be slid under the fascia to clear the median nerve and the vessels. After this has been done, the fascia is drawn tense and can be cut with safety under direct vision, slightly above the level of the superficial palmar arch, which may be located by abducting the thumb and drawing a line from the medial border to the center of the palm. It is probably unnecessary to excise more proximally, because no recurrence has been noted in this region of the palm.

Next, the distal skin is freed; it will usually be more extensively adherent than the skin in the proximal half. The dissection is carried down to the level of the webs and the base of the fingers.

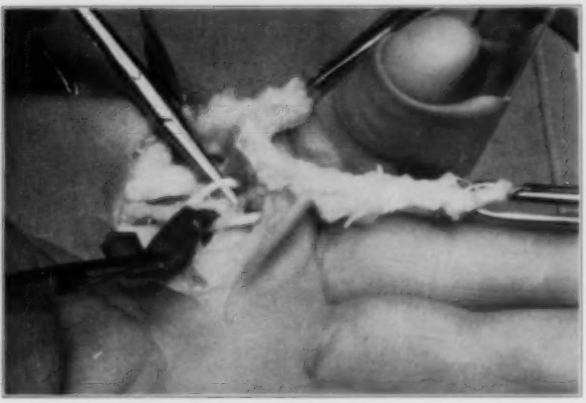

FIG. 4

The nerves and vessels are dissected as far as the base of the fingers; the dissection is simplified by putting them under tension by means of a rubber band.

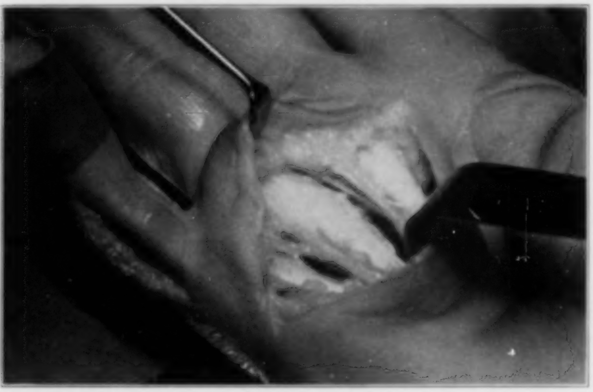

FIG. 5

Appearance of the palm after complete removal of the aponeurosis. Note the longitudinal incisions on the medial aspect of the proximal phalanx of the fifth finger.

The aponeurosis is then detached by working from the proximal portion of the wound to the distal portion. Care must be taken to avoid all the important structures, which are systematically sought for and retracted, such as the neurovascular bundles and the flexor tendons and their sheaths. They can always be freed as they are anatomically separate, however advanced the disease. One must not forget, in particular, to locate and preserve the digital branch of the ulnar nerve of the fifth finger, which is situated far medially.

The fascial septa start at the level of the proximal palmar crease. They extend distally on each side of the flexor tendons attached to the superficial and deep palmar fascia and send fibers to the metacarpals; a prolongation to the phalanges contributes to the maintainance of the contracture. Complete section usually allows total extension of the proximal phalanx.

After the division of all the deep septa, the fascia will now be attached only by its digital extensions. In an early case, with no diseased digital fascia, a little blunt dissection will divide the normal digital extensions and the fascia will come away in one piece.

When the digital aponeurosis is infiltrated, it must also be removed. To understand this portion of the operation, it may be helpful to recall the anatomy of the various fibrous formations, which have been described previously[6] (Fig. 6).

At the web, below the division of the neurovascular bundle, is a pad of fibrous tissue adherent to the web skin distally and the superficial transverse metacarpal ligament (natatory ligament) anteriorly. On either side it blends with the deep septal extension into the finger. The deep septum passes on into the finger, enclosing the lumbrical tendon between two layers. Only the resection of these transverse fibers at the web will allow lateral movement of the fingers. The digital slip, which is an extension of the superficial palmar fascia, passes deep to the vessels in the finger and blends with the extension of the deep septum. This septum inserts posteriorly into the lateral aspect of the first and second phalanx. It has numerous aponeurotic expansions which might undergo pathological changes: some, to the sides, surround the nerve and blood vessels; one, anterior to the

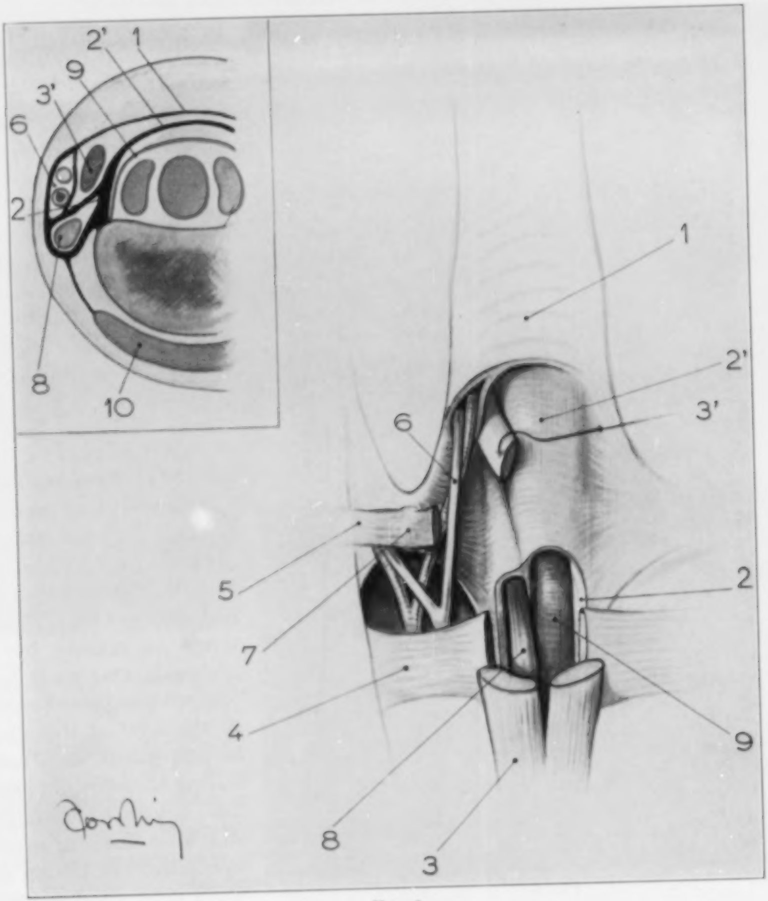

Fig. 6

Anatomical disposition of the digital aponeurosis.

*1:* Superficial digital aponeurosis.
*2:* Deep septal extension into the finger.
*2':* Ventral expansions of the septum in front of the flexor tendon sheath.
*3:* Digital slip, extension of the superficial palmar fascia divided at the base of the finger.
*3':* Phalangeal attachment of digital slip. *4:* Transverse fibers.
*5:* Superficial transverse metacarpal ligament (natatory ligament). *6:* Nerves and vessels.
*7:* Web aponeurotic nodule. *8:* Lumbrical tendon.
*9:* Flexor tendon sheath. *10:* Extensor tendon.
(Reproduced with modifications by permission of Masson et C^ie^. from *Revue de Chirurgie Orthopédique*, **38**: 355, 1952.)

flexor tendon sheath, reaches the opposite septum where it blends with the thin digital fascia which covers the anterior aspect of the finger like a tunnel; and one, posterior, is directed toward the extensor system.

These various aponeurotic formations are irregularly thickened and retracted; but it is of great importance, when they have undergone pathological changes, to remove them *from their phalangeal attachments*, if maximum extension at the interphalangeal joint is to be recovered.

Before undertaking excision of the fascia, one must begin by dissecting any digital nerves which are displaced laterally or medially, often in an unpredictable fashion. This is the most delicate part of the operation: if these nerves were cut, it would lead not only

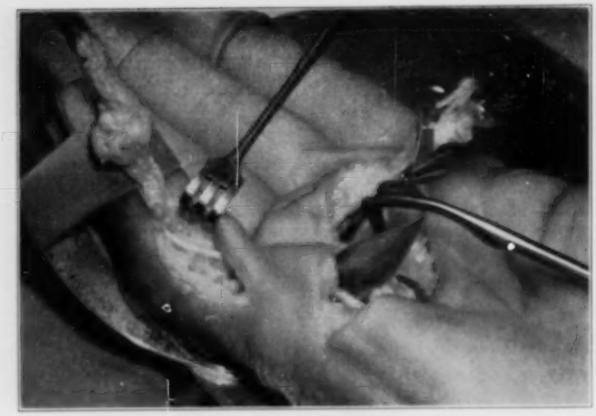

FIG. 7

Removal of digital aponeurosis.

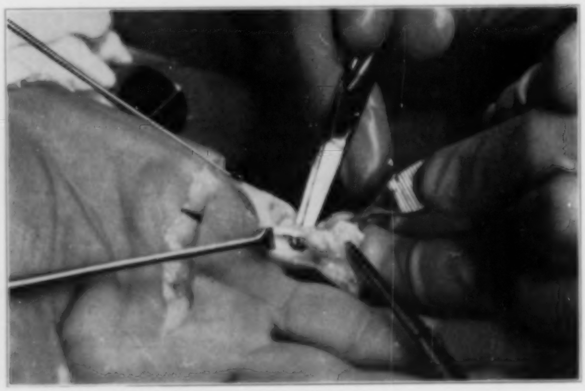

FIG. 8

Dissection of medial pedicle in a case in which Z plasty was performed.

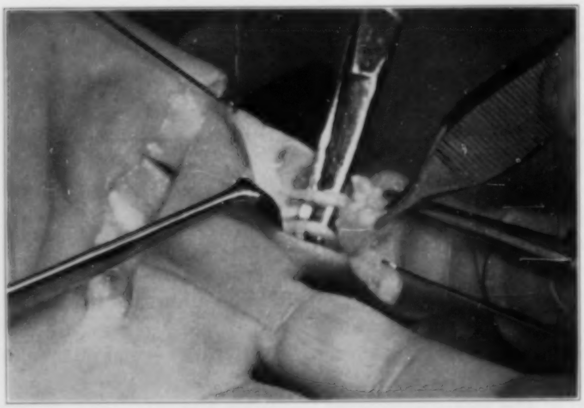

FIG. 9

Removal of digital aponeurosis after both digital nerves have been exposed.

to sensory disturbances but also to marked trophic complications.

It is of help to pull gently on the nerves liberated in the distal part of the palm, following them up to the root of the fingers, in order to locate them and then to isolate them at the level of the finger. The removal of the digital bands will allow a more or less complete extension of the second phalanx.

If a limitation of extension still persists, it indicates that there are other associated lesions, such as retraction of the fibrous sheaths of the tendons, which can be debrided, or articular retraction which we no longer attempt to remedy by direct approach. One must be content with imperfect extension at the level of the interphalangeal joints and not risk forcing these fragile joints by manoeuvres which might result in stiffness in extension. Limitations of flexion are always more troublesome than limitations of extension.

Prior to removing the cuff, when possible, the anaesthetist commences the controlled hypotension. The operated hand is elevated, and a solution of hexamethonium is injected intravenously.

Obviously, a good dissection will avoid the principal vessels, but sometimes, after the removal of the cuff and despite packing, diffuse bleeding persists at the level of the subcutaneous deep septa or from fatty tissue.

Completion of the operation under controlled hypotension has the following advantages:

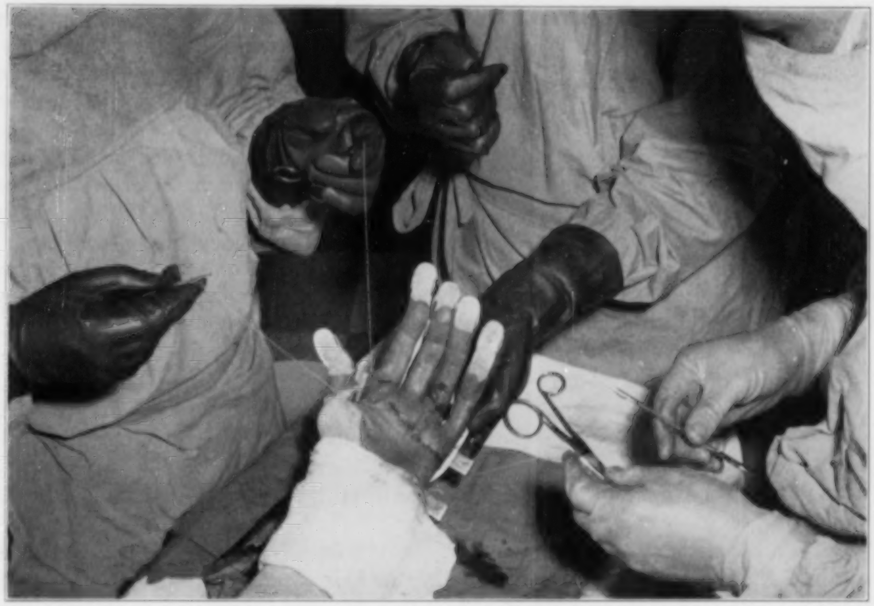

FIG. 10

Showing the skin closure and the four sutures, attached to the palm at the corners, which will be tied over a pressure dressing.

1. It facilitates a careful hemostasis in a clean operative field, with minimal bleeding;

2. It allows one to reduce the time of the operations under tourniquet pressure, particularly in those operations which are completed with a plastic repair;

3. It avoids postoperative hematomata, circulation being restored to normal only after the establishment of a pressure dressing;

4. This ganglionic blocking agent appears to affect favorably the outcome of the operation.

We have now employed controlled hypotension [10] in the *Clinique de Chirurgie Orthopédique et Réparatrice de la Faculté de Paris* in more than 500 selected cases without incident, under the guidance of Dr. Kern, the Chief Anaesthetist.

The candidates for controlled hypotension are carefully selected. All patients having any form of deficient oxygenation are eliminated, as for example:

a. Patients with deficient respiratory exchange, including obese patients;

b. Asthmatics, even those with good respiratory exchange, inasmuch as it is dangerous to block the sympathetic nervous system;

c. Patients with coronary disease, with anaemia, and those in shock;

d. Patients with renal deficiency;

e. Patients presenting adrenal deficiency, as well as all patients with hypotension.

Our present choice of medication for controlled hypotension is Arfonad [7], which presents the advantage over the salts of methonium of having a brief duration of action. Elimination is so rapid that the drug must be administered intravenously at the rate of ten to twenty drops per minute of a solution of 0.5 milligram per cubic centimeter of physiological saline. However, in surgery of the hand, particularly in Dupuytren's contracture, we continue to employ salts of methonium which has a longer period of action. This agent is, of course, less easily controlled, but we have used it in very small doses since the majority of these operations are performed under tourniquet.

In general, five minutes before removal of the tourniquet, twenty-five milligrams of hexamethonium are injected intravenously, the patient's hand being elevated and the lower extremities and the head being lowered. The blood pressure is followed carefully; the systolic pressure should not fall below eighty. The action of the drug continues for approximately one hour. If it is desirable to prolong the period of ganglionic paralysis during the immediate postoperative period, one may proceed with a second injection, providing that the drop in blood pressure resulting from the first injection had not been excessive. Twenty-five to fifty milligrams are injected by the intramuscular route in the second injection when the blood pressure is starting to rise. The action of the anaesthetic injected by way of the intramuscular route is less marked and more prolonged.

If hypotensive anaesthesia is not employed, then the tourniquet is utilized in the routine fashion to control bleeding during the operation; it is removed while bleeders are controlled, and then is re-applied while the pressure dressing is applied.

## SKIN REPAIR

Finally, there is the question of skin repair. We have become more conservative and we try to avoid cutaneous excisions; usually, we are able to close the incision with steel-wire sutures.

Sixteen of our patients have undergone plastic surgery; free grafts have been used in nine and flaps in seven.

All of the plastic procedures have been reserved for advanced cases. On the whole, the results show an improvement, but we have had six cases of partial necrosis (in five after free grafts were used and in one after a flap was used), requiring re-grafting procedures in three and limitation of articular mobility in four cases.

It is now our opinion that the plastic stage can often be avoided, since the skin becomes more elastic following operation. If skin covering is required, we prefer a local flap, taken from the dorsal surface of the hand and carried up to the fifth finger after the method of Bruner, this in preference to free grafts which, despite some good results, have shown too high a percentage of slight necrosis.

It is most important to obtain complete healing as soon as possible. Delayed healing and separation of the sutured edges are factors in subinfection and oedema and hinder the restoration of movements. For this reason, we avoid any procedure which would cause tension on the scar, as well as the use of free grafts, which have given us a much higher incidence of partial necrosis than the preservation of scar-infiltrated skin.

The dressing is an important part of the operation. A large bolus pressure dressing is held in position by sutures in the corners of the palm, the long ends of which are passed over the bulky dressing and tied, as advocated by Mason. The metacarpophalangeal joints are placed in flexion to avoid traction on the palmar incision. An elastic bandage is firmly applied, thus constituting a splint which maintains the hand in the position of function; the interphalangeal joints are left free, so that they may be actively exercised. The hand is elevated, and the patient is kept in the hospital for at least three days. On the eighth day, the dressing is changed. In some cases, we have injected two cubic centimeters of hydrocortone locally, which appears to reduce the scarring. (Treatment of Dupuytren's contracture by injections of hydrocortone alone, instead of by surgery, have given only poor or no results.) The skin sutures are only removed at the end of three weeks. The patient usually returns to work at the end of four or five weeks.

The most important complications are hematomata, oedema, and stiffness of the joints. With careful surgery and meticulous after-care, these may be avoided.

It is possible that etiological factors may be partially responsible for poor results; however, that seems to be too simple an answer in most cases. In our experience, the majority of postoperative complications have been the result of faulty technique or errors of estimation. Possibly in no other type of surgery can such errors so seriously affect functional ability as in the hand.

Recurrences which indicate a developmental tendency of the disease are more difficult to control. We have observed four * such cases, which were followed from six months to five years, in patients upon whom we had previously operated. In only one case was it necessary to carry out revisionary surgery; in this case, arthrodesis was done in the fifth finger. One should distinguish between the occurrence of nodules at the operative site and their occurrence in other areas of the hand. In two cases, the recurrences were evident in the fingers previously affected, in the fifth finger in one patient and in the fourth in another. The latter patient was an old man who, because of his age, had had only a limited aponeurectomy. On two occasions, we have seen secondary nodules at the level of the thumb and index fingers which had not been operated upon.

We have operated for relapses in seven patients who had previously been operated upon one or more times elsewhere. Three of these patients had epilepsy (in one of these, we observed the appearance of a new nodule after our re-operation); one patient had a marked periarthritis of the shoulder; one patient had plantar nodules and elastic knuckle pads; and in two patients, the original contracture had been localized in the fifth finger. However, it is unwise to give too much importance to these etiological factors, since fasciectomy may have been incomplete, especially at the level of the fingers.

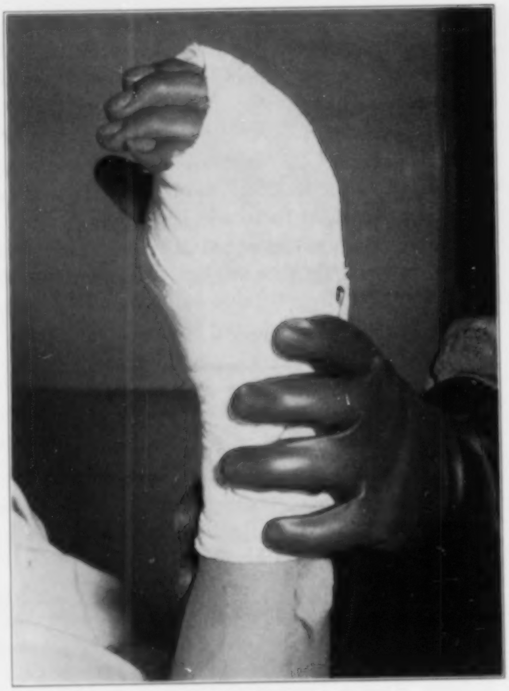

FIG. 11

Showing the dressing. The metacarpophalangeal joints are maintained in flexed position, but the interphalangeal joints are left free to move.

The presence of fibrous changes elsewhere would perhaps justify an attempt at general therapy directed against the modification of connective tissue; but the use of vitamin E, heparine, or cortisone has given only very irregular results[6].

## RESULTS

Removal of palmar fascia in a series of fifty-six hands examined after a variable follow-up period of six months to five years has given the following results: 43 per cent. *very good*, 34 per cent. *good*, 20 per cent. *fair*, and 3 per cent. *poor*.

Other than the cases considered in these tables, we have also treated, secondarily, ten patients (fourteen hands) who had already been operated upon elsewhere for Dupuytren's contracture and who presented recurrences or sequelae. The problems in these cases varied. Some patients had only cutaneous sequelae, contractures which had occurred as a result of vertical incisions across transverse creases, for which Z plasties or grafts were performed. Sometimes, the removal of palmar fascia had been correctly performed, but the digital stage had not been included, and it became necessary to complete the excision. Some of these hands had been brought to us in a useless state,—with stiff fingers, contracted and oedematous. In these patients, it was necessary to perform arthrodesis of the fingers in a position of function or to amputate one or more fingers, utilizing the skin flaps as a supply for the palmar skin. Eight of the hands treated for sequelae were considerably improved; six were improved to a lesser degree.

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* Since this was written, nodules have developed at a distance from the site of the original operation in two other patients of this series.

## CONCLUSIONS

In a series of 100 cases of Dupuytren's contracture, it has been found that the site and degree of the lesions, the choice of treatment, and the surgical technique constitute the most important factors in prognosis.

Complete removal of palmar fascia, including the palmar and digital lesions, appears to be the most effective treatment for this condition.

Controlled hypotension in conjunction with tourniquet compression has been employed in a series of selected cases.

## REFERENCES

1. Bruner, J. M.: Use of Dorsal Skin Flap for Coverage of Palmar Defect after Aponeurectomy for Dupuytren's Contracture. Plast. and Reconstruct. Surg., **4:** 559–565, 1949.
2. Bunnell, Sterling: Surgery of the Hand. Ed. 2. Philadelphia, J. B. Lippincott Company, 1948.
3. Desplas, B.: À propos de la maladie de Dupuytren. Mém. de l'Acad. de Chir. de Paris, **77:** 425–428, 1951.
4. Einarsson, Fridrik: On the Treatment of Dupuytren's Contracture. Acta Chir. Scandinavica, **93:** 1–22, 1946.
5. Iselin, M., et Dieckmann, G.: Notre expérience du traitement de la maladie de Dupuytren. Mém. de l'Acad. de Chir. de Paris, **77:** 251–255, 1951.
6. James, J., et Tubiana, R.: La maladie de Dupuytren. Rev. de Chir. Orthop., **38:** 352–406, 1952.
7. Kern, E.; Schwartz, M.; Vincent-Espinasse, J.; et Fernandez, Y.: L'hypotension contrôlée par l'Arfonad, ganglioplégique à action fugace; premiers résultats cliniques. Anesthésie et Analgésie, **11:** 631–641, 1954.
8. Lund, Mogens: Dupuytren's Contracture and Epilepsy. The clinical connection between Dupuytren's contracture, fibroma plantae, periarthrosis humeri, helodermia, induratio penis plastica and epilepsy, with an attempt at a pathogenetic valuation. Acta Psychiat. et Neurol., **16:** 465–491, 1941.
9. McIndoe, A.: cited in [15].
10. Mason, M. L.: Dupuytren's Contracture. Surg. Clin. North America, **32:** 233–245, 1952.
11. Merle d'Aubigné, R., et Kern, E.: Chirurgie exsangue par hypotension contrôlée. Mém. de l'Acad. de Chir. de Paris, **77:** 775–778, 1951.
12. Meyerding, H. W.: Dupuytren's Contracture. Arch. Surg., **32:** 320–333, 1936.
13. Meyerding, H. W.: The Treatment of Dupuytren's Contracture. Am. J. Surg., **49:** 94–103, 1940.
14. Meyerding, H. W.; Black, J. R.; and Broders, A. C.: The Etiology and Pathology of Dupuytren's Contracture. Surg., Gynec., and Obstet., **72:** 582–590, 1941.
15. Padovani, P., et Lord, G.: Arthroses cervicales et maladie de Dupuytren. Sem. des Hôp. de Paris, **45:** 1955–1956, 1951.
16. Skoog, T.: Dupuytren's Contraction. Acta Chir. Scandinavica, **96:** Supplementum 139, 1948.
17. Tostivint, R.: De la maladie de Dupuytren. À propos de 85 malades et 100 opérations faites. Thése Paris, No. 285, 1944.
18. Tubiana, R.; Houpis, H.; et Lataste, J.: Recherches étiologiques et pronostiques sur la maladie de Dupuytren. Sem. des Hôp. de Paris, **30:** 213–226, 1954.

# LATE EFFECTS (TWENTY-FIVE TO FORTY YEARS) OF THE EARLY MEDICAL AND INDUSTRIAL USE OF RADIO-ACTIVE MATERIALS

## Their Relation to the More Accurate Establishment of Maximum Permissible Amounts of Radio-Active Elements in the Body *†

## Part I**

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### INTRODUCTION

The study of the late effects of internally deposited radio-active materials has been made primarily on individuals who had received radium for medical purposes and individuals who had been employed in the luminous-dial-painting industry. Radium salts had been given orally and intravenously for hypertension, arthritis, anaemia, and other medical disorders from about 1915 to 1930 [14]. The rationale for the medical use of radium was based on the belief that it relieved pain, that it activated enzymes, and that it reduced blood pressure [23]. The painting of watch dials with luminous material containing radium, mesothorium, and radio-active thorium started in this country about 1915 [3]. Adequate safety measures were not taken until about 1925 to 1927 following the deaths from bone tumors, anaemia, and crippling bone lesions that occurred in some of these workers [20].

Recent investigations (1951) of these individuals who had received radio-active materials from 1915 to 1930 have shown that clinical changes developed many years after the deposition of the radio-active elements [3, 15]. Bone tumors and skeletal changes have occurred fifteen to thirty years after the administration or the ingestion of the radio-active materials. The information gained from these studies on the late effects of internally deposited radio-active material is of considerable importance for the following reasons:

1. The clinical information will serve as a guide for the diagnosis, management, and treatment of patients who will receive or will ingest harmful amounts of radio-active materials in use today;
2. The radiobiological data obtained by new and refined techniques have given a better understanding of the manner in which changes are produced by internally deposited radio-active elements;
3. The information can be used to establish more accurately maximum permissible levels of body burden.

The amount of radio-active material that can be safely retained by the body is known as the maximum permissible level for a specific radio-active element. The maximum

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† The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or as reflecting the views of the Navy Department or of the Naval Establishment at large.

** This is the first of three parts of a thoroughgoing analysis. Parts II and III will appear in the January and April issues, respectively, of *The Journal.*

*** From 1950 to 1952, the author was a Post-Doctorate Atomic Energy Commission Fellow in the Medical Sciences of the National Research Council at the Argonne National Laboratory. He was assigned the responsibility for the clinical aspects of the investigation of individuals who had been given radium salts and people who had been employed as luminous-dial workers (1915 to 1930) and the responsibility for the correlation of the clinical aspects with the biophysical aspects of the investigation. This investigation was conducted by the following: Dr. A. M. Brues, Dr. L. D. Marinelli, Dr. W. P. Norris, Dr. R. J. Hasterlik, and Dr. A. H. Stehney, their associates, and the author. The histopathological studies were made at the Department of Orthopaedic Surgery, University of Chicago, with Dr. C. Howard Hatcher. Detailed reports of the various phases of the investigation will be published.

The author was afforded the privilege of reviewing the clinical data of a similar investigation carried out at the Harvard Medical School and the Massachusetts Institute of Technology by Dr. J. C. Aub, Dr. R. D. Evans, Dr. L. H. Hempelmann, and Dr. M. S. Martland.

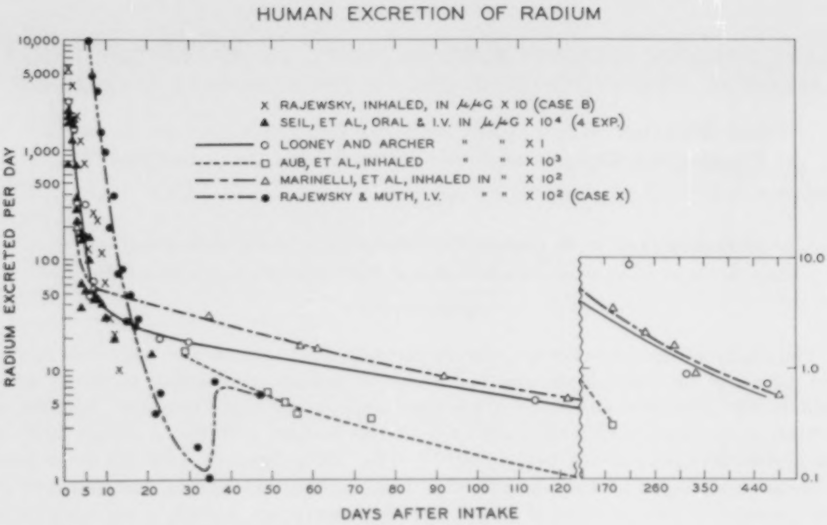

CHART I-A

Charts I-A and I-B are republished by permission from "Radium Elimination Following a Radium Accident" by W. B. Looney and V. E. Archer. *American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine, in press.*

permissible levels for radio-active materials in medical, military, and industrial use today are based in large measure on radiobiological data obtained from the luminous-dial workers and the patients given radium. It has become evident from these recent investigations that an extensive study of at least one generation will probably be necessary before reliable maximum permissible levels of exposure are established.

In 1941, the National Bureau of Standards made the following report [5]. Seven individuals having between .02 and .5 microgram of radium in their bodies from seven to twenty-five years had no noted changes referable to the deposition of radio-active elements. However, death had occurred in patients having as little as 1.2 micrograms of radium. The maximum permissible level of body burden for the amount of radium which remains after the early rapid elimination was considered to be 0.1 microgram.

The principal human data which are available for directly establishing permissible levels of body burden have been obtained from the clinical effects of radium. This information is very useful in establishing permissible levels of body burden for radio-active elements for which clinical data are not available. The maximum permissible level of plutonium was established by giving groups of laboratory animals plutonium and radium. When the relative toxicity of plutonium and radium had been determined, these animal data and the data on the toxicity of radium in man were used to establish the permissible body burden for plutonium in man [6].

### RADIUM ELIMINATION

Radium is considered to be dispersed throughout the soft tissues and the skeleton when it first has been taken into the body [7]. Most of the radium is eliminated during the first week[26, 27] (Chart I-A). Fecal excretion is the major route of elimination in early and late cases. From 90 to 97 per cent. of the radium which is eliminated is eliminated in the faeces and only 3 to 10 per cent. is eliminated in the urine[2, 21, 27]. It has been reported that the rate of elimination following inhalation or ingestion is more rapid than that following intravenous administration [24, 26]. Results from recent studies, however, indicate that these

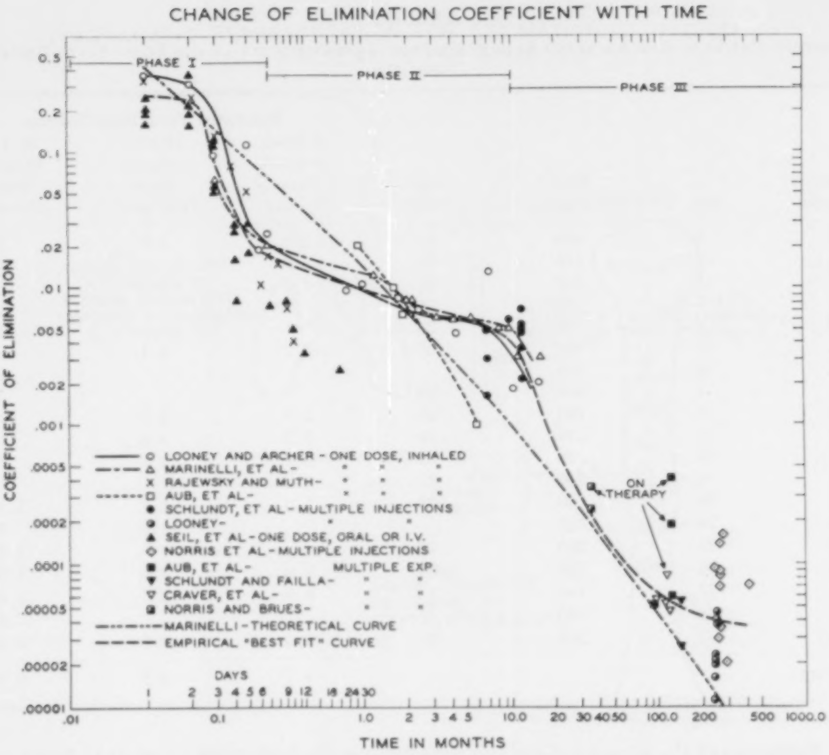

CHART I-B

differences in the rate of elimination are not so pronounced as it was previously thought[16, 19, 21]. Within a matter of months, 90 to 99.9 per cent. of the radium is eliminated[25, 27]. The age, the total amount of radium injected, and the estimates of the injected dose in nineteen patients at six months, twelve months, and twenty years, are given in Table I. The average amount of the injected radium remaining at the times these estimates were made was 4.7 per cent., 2.2 per cent., and 0.8 per cent., respectively.

The amount of the remaining radium eliminated daily becomes less and less[17]. The available clinical data on the coefficient of elimination * of radium are given in Chart I-B[16]. The marked change in the coefficient of elimination at one week has been considered to be the result of the elimination of the principal portion of radium from the soft tissues and the gastro-intestinal tract (Phase I) and the change at one year has been considered to be the result of the elimination of the principal portion of radium from the more accessible parts of the skeleton (Phase II). It is reasonable to conclude that the decreasing rate of elimination of radium is from the more inaccessible parts of the skeleton after one year (Phase III).

About 15 to 35 per cent. of the absorbed radium is eliminated the first day. The amount of the remaining radium eliminated daily after one week is less than 1 per cent[26]. After about ten years, it varies from .002 to .009 per cent. of the body content[24]. The coefficient of elimination after about twenty years varies from about .002 to .016 per cent. of the body content[21, 27].

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* The coefficient of elimination is equal to the amount of radium eliminated per unit time (days) divided by the amount of radium in the body at the time the elimination measurements were made.

### TABLE I

NINETEEN PATIENTS WHO RECEIVED RADIUM CHLORIDE INTRAVENOUSLY AT THE ELGIN STATE HOSPITAL 1930–1931

| | | | | Estimated Total Body Radium | | |
|---|---|---|---|---|---|---|
| Patient Initial | No. | Dose (*Micrograms*) | Age (1931) | 6 Mos. Original Dose (*Per cent.*) | 12 Mos. Original Dose (*Per cent.*) | 20 Yrs. Original Dose (*Per cent.*) |
| C.C. | 2 | 150 | 63 | 2.5 | 1.1 | .3 |
| P.N. | 3 | 110 | 23 | | | .5 |
| O.W. | 5 | 150 | 27 | 4.0 | 2.1 | .3 |
| L.P. | 7 | 70 | 51 | | | .9 |
| R.M. | 8 | 90 | 28 | | | .7 |
| E.A. | 11 | 180 | 28 | 3.7 | 1.1 | .4 |
| C.D. | 12 | 450 | | | | .2 |
| G.Z. | 14 | 200 | 22 | | | .5 |
| G.N. | 15 | 260 | 25 | 2.9 | 1.2 | .4 |
| D.D. | 16 | 110 | 18 | 8.3 | 4.8 | .9 |
| V.Mc. | 17 | 200 | 31 | 3.1 | 2.2 | .5 |
| E.J. | 13 | 260 | 23 | | | .3 |
| C.S. | 23 | 150 | 22 | 5.5 | 2.3 | 1.1 |
| A.M. | 24 | 360 | | | 1.8 | .5 |
| R.D. | 25 | 200 | 22 | | | 1.0 |
| L.W. | 26 | 250 | 23 | 2.8 | 2.6 | 1.0 |
| F.P. | 27 | 160 | 29 | 8.6 | 3.4 | 1.6 |
| C.L. | 28 | 410 | 32 | | | .9 |
| D.A. | 32 | 260 | 25 | 5.5 | 2.0 | 2.6 |
| Average | | | | 4.7 | 2.2 | 0.8 |

Estimates of the amount of radium remaining in the body may be made in four ways:

1. Collection of the breath radon and assuming a certain radon to total body radium ratio (Fig. 1). About .02 microgram of radium in the body can be detected by this method. Variations in the estimates may be 100 per cent. or more; this variation seems to be primarily the result of fluctuations in breathing. More refined techniques of continuous sample collecting have reduced this error to about 10 per cent [27].

2. About .05 microgram of radium can be detected by external measurements with the scintillation counter *. This is the most reliable method, since the subjective status of the patient does not significantly enter into the measurements. Results are accurate to about 5 to 10 per cent.[18]

3. Estimates of the radium body content may be made by radiochemical analysis of the excreta. This method can detect smaller amounts of radium in the body shortly after radium intake than methods *1* and *2* when the coefficient of elimination is high (Chart I-B). The sensitivity of the method is comparable to methods *1* and *2* in chronic cases. Estimation of the retained radium from excreta may vary by a factor of four to eight in chronic cases. One advantage of this method is that the presence of radium can be established by the analysis of a twenty-four to forty-eight hour fecal specimen.

4. Estimates of the amount of radium in the body may be made by determining the amount of radium present in bone specimens or bone biopsy specimens. These may vary by a factor of ten in estimates of a single specimen; however, closer approximation may be made by averages of determinations from different bones [21]. (See section on The Manner of Radium Deposition in the Body, *B.*) This method is impractical for use as a routine clinical procedure.

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* More refined techniques may permit the determination of much smaller amounts of radium.

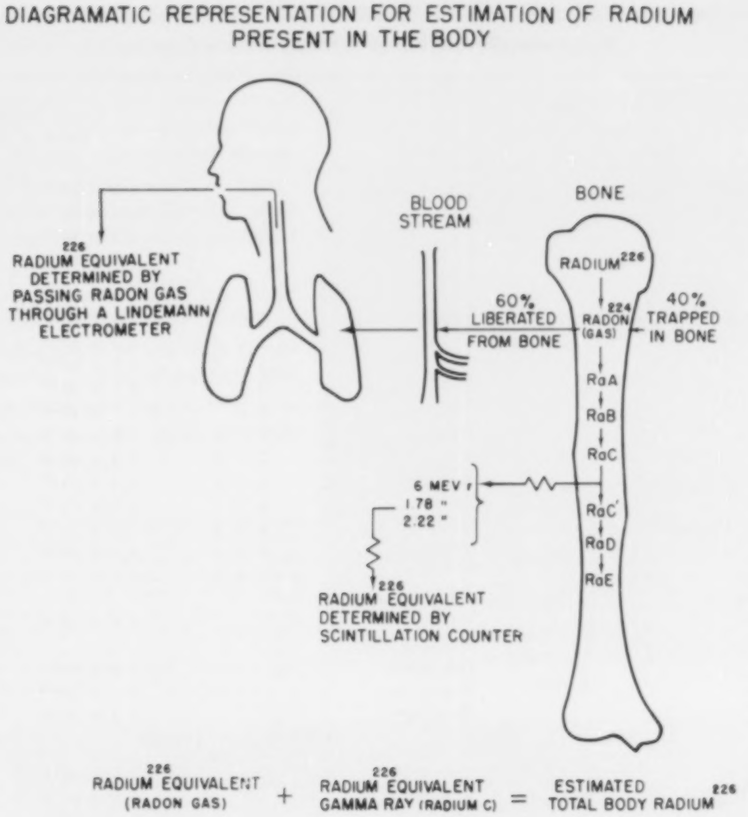
DIAGRAMATIC REPRESENTATION FOR ESTIMATION OF RADIUM PRESENT IN THE BODY
226 RADIUM EQUIVALENT DETERMINED BY PASSING RADON GAS THROUGH A LINDEMANN ELECTROMETER
BLOOD STREAM
BONE
RADIUM 226
60% LIBERATED FROM BONE
224 RADON (GAS)
40% TRAPPED IN BONE
RaA
RaB
RaC
6 MEV r
1.78 "
2.22 "
RaC′
RaD
RaE
226 RADIUM EQUIVALENT DETERMINED BY SCINTILLATION COUNTER
226 RADIUM EQUIVALENT (RADON GAS) + 226 RADIUM EQUIVALENT GAMMA RAY (RADIUM C) = ESTIMATED TOTAL BODY RADIUM 226

FIG. 1

### ESTIMATION OF RETAINED RADIUM

The most practical and the most reliable method of the determination of the radium remaining in the body is by external counting and collection of expired air from the patient [9, 18, 27]. The first daughter product of radium is radon, an inert gas with a 3.8 day half-life. About 50 to 70 per cent. of the radon produced is eliminated in the expired air. The remaining 30 to 50 per cent. is trapped in the skeleton or in the body tissues. The fraction of the radon trapped in the body is estimated by determining the gamma-ray activity given off by the decay of the daughter products of radon. The estimation of all the radium remaining in the body is the sum of the estimated radium which produced the radon in the expired air and the estimated radium trapped in the body to produce the gamma-ray activity (Fig. 1).

Estimates of the total body radium have been made by using only radon breath values and by assuming that 50 per cent. of the radon is eliminated and 50 per cent. is trapped in the body. Since the radon to radium ratio may vary from 0.4 to 0.8, the most reliable estimation is the measurement of both the radon breath and the retained component of the radium decay series.

### THE MANNER OF RADIUM DEPOSITION IN THE BODY

### A. *Autoradiographic Study of Radium Deposition*

Entire bones were sectioned serially and a comprehensive picture of distribution

TABLE II

RADIOCHEMICAL ANALYSIS OF SKELETAL RADIUM CONTENT

| Patient | Total Body Radium (*Micrograms*) | Bone | Sample No. | Curies Radium to Gram of Bone | |
|---|---|---|---|---|---|
| H.V. (R-13) | .9 | Femur (head) | A | $1.2 \times 10^{-10}$ | |
| | | | B | $6.51 \times 10^{-10}$ | |
| | | | C | $5.2 \times 10^{-10}$ | |
| | | Fibula | | $1.1 \times 10^{-10}$ | |
| | | | Average | | $3.5 \times 10^{-10}$ |
| M.K. (R-24) | 1.3 | Humerus | 5 C 1 | $12 \times 10^{-10}$ | |
| | | | 5 C 2 | $1.1 \times 10^{-10}$ | |
| | | | 5 C 3 | $5.6 \times 10^{-10}$ | |
| | | Skull | 6 Q | $9.7 \times 10^{-10}$ | |
| | | | 6 R | $5.7 \times 10^{-10}$ | |
| | | Tibia | 7 C 1 | $1.6 \times 10^{-10}$ | |
| | | | 7 I 3 | $3.3 \times 10^{-10}$ | |
| | | Femur | 8 D 6 | $1.3 \times 10^{-10}$ | |
| | | | 8 D 7 | $6.7 \times 10^{-10}$ | |
| | | | 8 I 2 | $10 \times 10^{-10}$ | |
| | | Fibula | 9 A 6 | $1.5 \times 10^{-10}$ | |
| | | | 9 A 8 | $9.5 \times 10^{-10}$ | |
| | | *Amputated Leg* | | | |
| | | Tibia | | $2.6 \times 10^{-10}$ | |
| | | *Bones of Feet* | | | |
| | | Calcaneus | | $3.0 \times 10^{-10}$ | |
| | | Tumor area | | $5.7 \times 10^{-10}$ | |
| | | Cuneiform | | $5.3 \times 10^{-10}$ | |
| | | | Average | | $5.3 \times 10^{-10}$ |
| M.H. (R-47) | 11.2 | Mandible | | $1.7 \times 10^{-9}$ | |
| M.L. (L-27) | | Vertebrae | | $5.5 \times 10^{-9}$ | |
| | | Ilium | | $2.9 \times 10^{-9}$ | |
| | | Rib | | $3.1 \times 10^{-9}$ | |
| | | | Average | | $3.8 \times 10^{-9}$ |

throughout the entire bone was obtained by placing the sections on roentgenographic film[3, 13] (Figs. 2, 8, 12, and 13). The precise manner of the deposition of radium was obtained by detailed autoradiography[1, 10, 13] (Figs. 6, 7, and 14). Histological sections were covered with a photographic emulsion. After the emulsion and staining had been developed, simultaneous study of radium deposition and histopathological change was made.

Radium was found in small areas of high focal concentration irregularly distributed in both compact and cancellous bone. In compact bone only a small percentage of the Haversian systems and interstitial lamellae had appreciable concentrations of radium (Figs. 12, 13, 14, and 15). In some instances radium was concentrated in one or two concentric lamellae, in other instances it was deposited around the central canal or periphery of the Haversian system.

The areas of radium concentration in trabecular bone were usually five to fifteen micra in the greatest dimension. However, there was a wide range in size and shape of these areas, and they were found at any depth within the trabecula. In some instances linear concentrations ran parallel to the curvature of the trabecula for fifty to 100 micra (Fig. 7). Heavy and rather uniform concentrations of radium were present at the junction of the articular cartilage and the trabeculae of the long bones in the gross autoradiographs. In the study by gross autoradiography it was found that frequent small highly concentrated areas resulted in outlining the bone contours (Fig. 8). Some cementing lines were clearly outlined by heavy concentrations of radium.

In some sections exposed for long periods of time there was a much less concentrated and a much more uniform distribution of radium. These findings are in agreement with existing theories that radium has more than one principal mode of deposition. The small highly concentrated areas may have been areas in which bone formation was taking place at the time of administration or redistribution. The more uniform and less dense distribution may be the result of inorganic ion exchange [13].

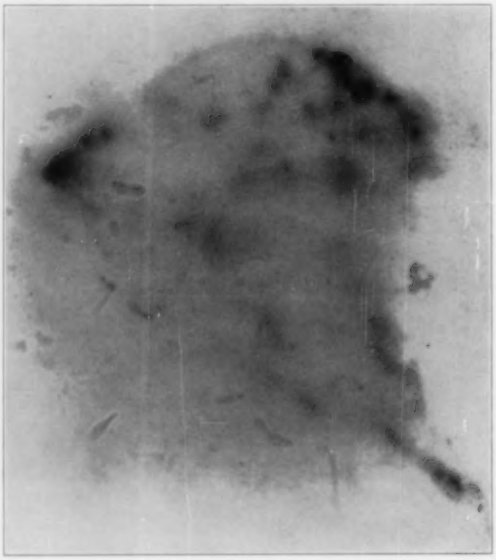

FIG. 2

Fig. 2: Gross autoradiogram of the head of a right humerus. It was exposed from February 1, 1952, to March 14, 1952. Note the areas of concentration of radium near the inferior articular surface of the head of the humerus. It was here that areas of increased density were seen roentgenographically. (Courtesy of Dr. A. M. Brues, Division of Biological and Medical Research, Argonne National Laboratory.)

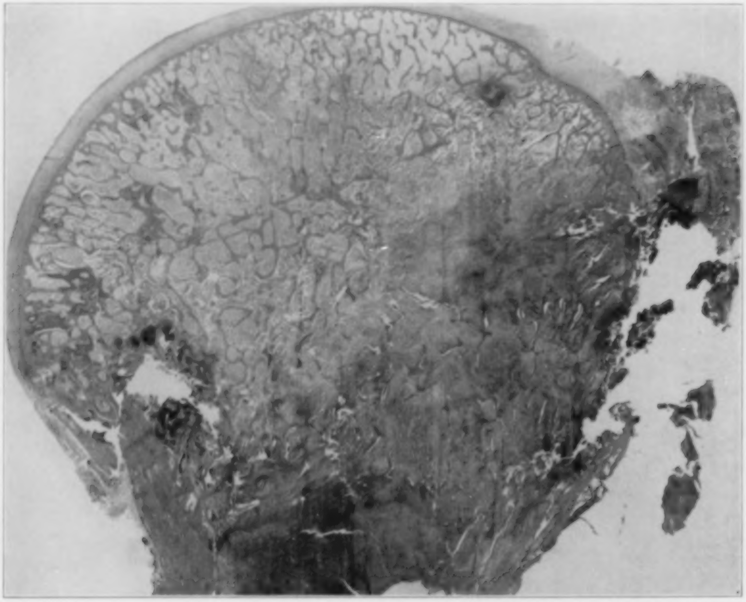

FIG. 3

Histological section of the head of a right humerus (Fig. 2). Note the areas of atypical osseous tissue throughout the head. The largest area of atypical osseous tissue is seen at the left of the photograph near the articular surface. (Courtesy of Dr. C. Howard Hatcher, Department of Orthopaedic Surgery, University of Chicago.)

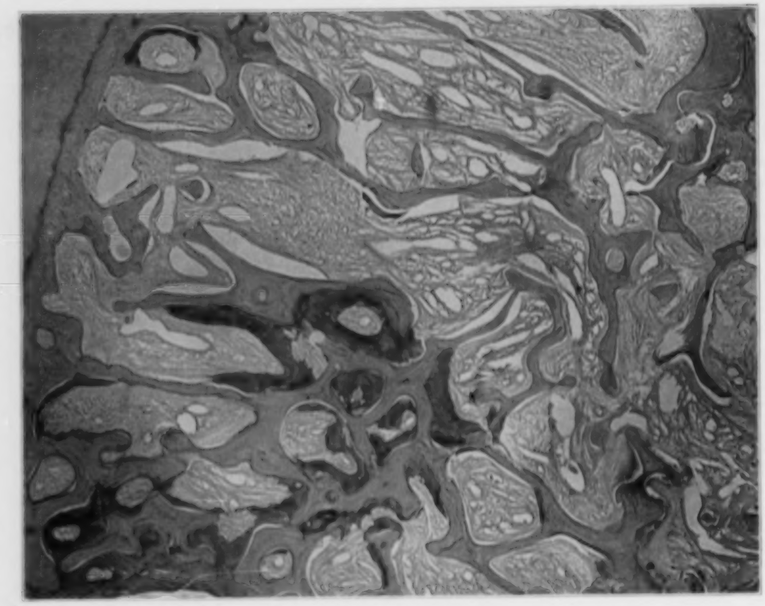

FIG. 4

Photomicrograph of one of the areas of atypical osseous tissue seen in the histological sections. The articular cartilage is shown on the left. The acellular fibrous tissue is seen throughout the trabecular spaces. (Courtesy of Dr. C. Howard Hatcher, Department of Orthopaedic Surgery, University of Chicago.)

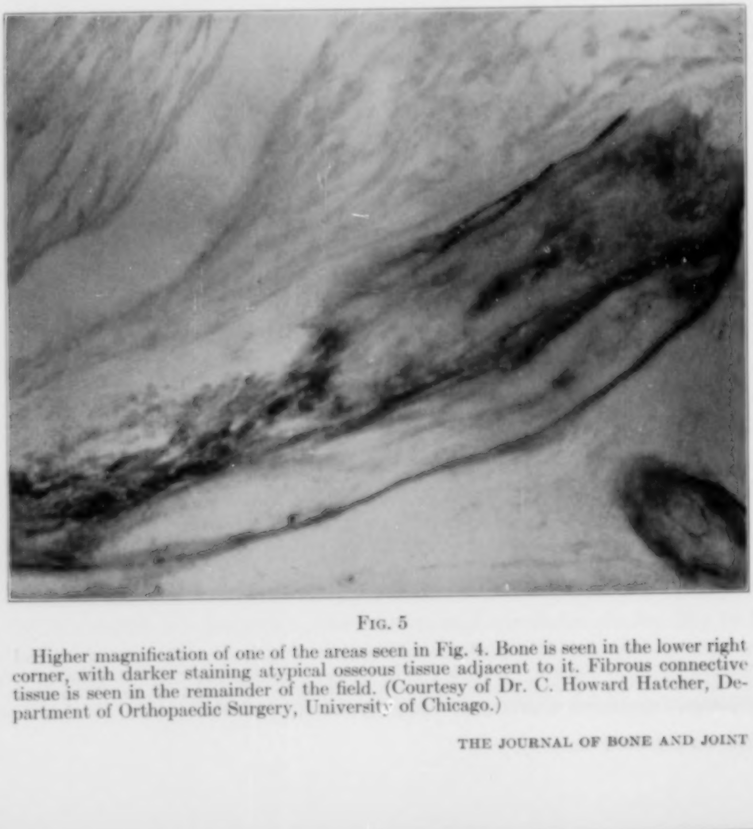

FIG. 5

Higher magnification of one of the areas seen in Fig. 4. Bone is seen in the lower right corner, with darker staining atypical osseous tissue adjacent to it. Fibrous connective tissue is seen in the remainder of the field. (Courtesy of Dr. C. Howard Hatcher, Department of Orthopaedic Surgery, University of Chicago.)

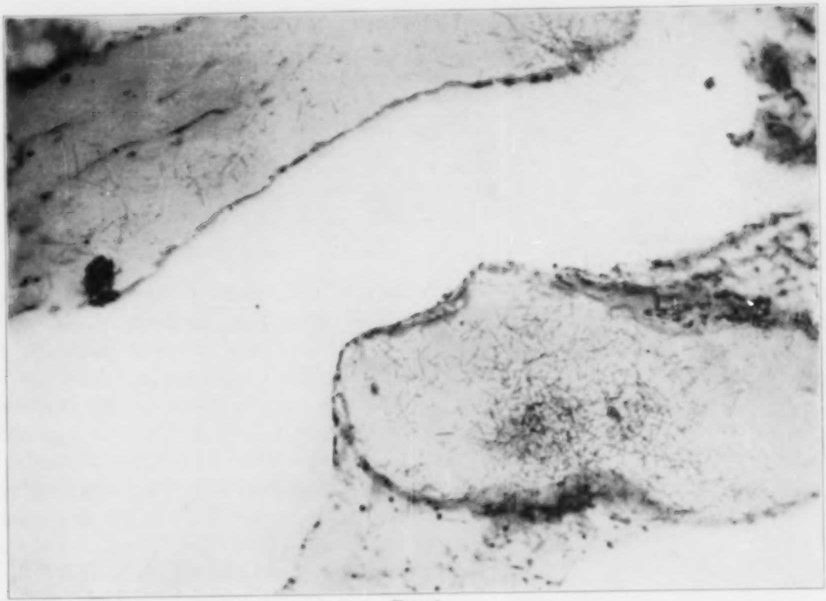

FIG. 6

Detailed autoradiogram showing the alpha tracks of radium deposited in the cancellous bone. The bone was taken from the head of the right femur during a reconstruction operation on the head of the femur. Patient H. V. (R-13), 134-day exposure. Trabecula at the right has radium concentrated in the center; that on left has small concentrated area at its superior border (× 275).

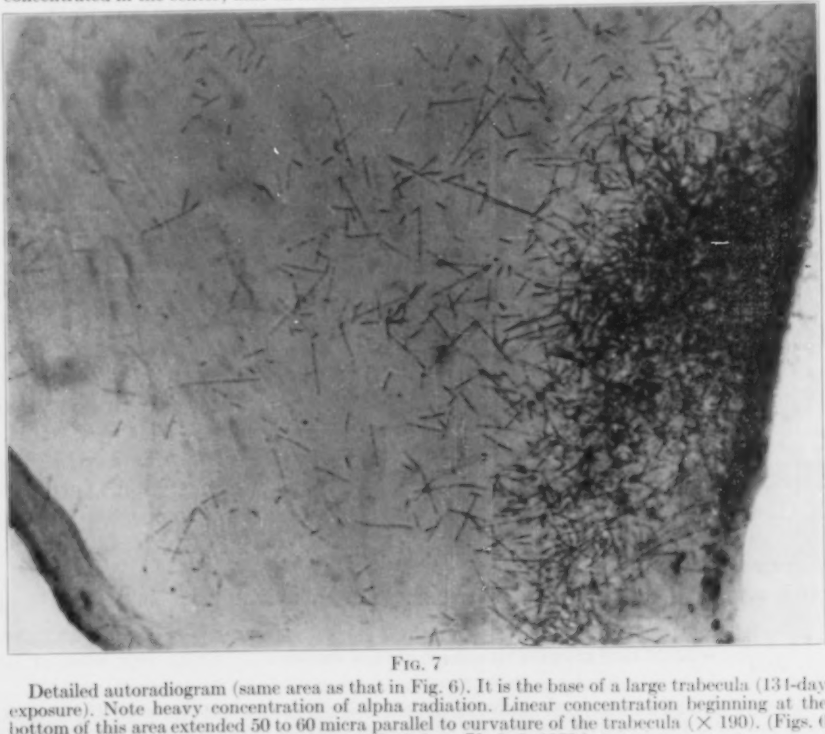

FIG. 7

Detailed autoradiogram (same area as that in Fig. 6). It is the base of a large trabecula (134-day exposure). Note heavy concentration of alpha radiation. Linear concentration beginning at the bottom of this area extended 50 to 60 micra parallel to curvature of the trabecula (× 190). (Figs. 6 and 7 reproduced from *A.M.A. Archives of Pathology*, **56**: 8, 9, 1953.)

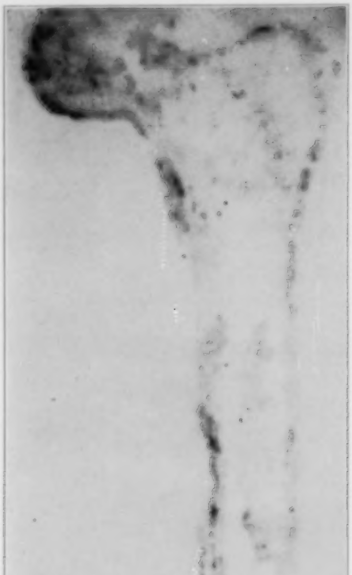

FIG. 8

Fig. 8: Gross autoradiogram of a longitudinal section of the femur of patient M. K. Note the irregular distribution of radium in the cancellous bone of the upper end of the femur and the small areas of focal concentration in the cortex. The contour of the head is outlined by small concentrations at the junction of the articular cartilage and cancellous bone (Fig. 9). The medial portion of the shaft is outlined by the small highly concentrated areas near the periosteum and the endosteum. (Courtesy of Dr. A. M. Brues, Division of Biological and Medical Research, Argonne National Laboratory.)

### B. *Radiochemical Study of Radium Deposition*

Numerous radiochemical analyses were made on bone specimens from patient M. K. (R-24). Samples were taken from different bones and from different parts of the same bone in order to see what the variations in radium concentration in the same bones would be, as well as the variations in radium concentration in the different bones of the body. The values of the radium concentration per gram of ashed bone varied by a factor of six in the four samples from patient H. V. (R-13) and by a factor of two in the three samples from patient M. L. (L-27)[21].

There was an estimated total body radium of 1.3 micrograms in this patient, who weighed fifty-nine kilograms. If we assume that one-tenth of the body weight is skeleton[11], then the average radium concentration in the skeleton is $2.2 \times 10^{-10}$ grams of radium per gram of wet bone*. The average concentration of the sixteen samples taken from patient M. K. was $5.3 \times 10^{-10}$ grams of radium per gram of ashed bone. Since the ashed weight varied from about one third to one fifth of the wet weight, an average correction of one-fourth of the wet weight was used as a correction factor. By multiplying the average value for the bone samples by one-fourth, the estimated average amount of radium in the skeleton is $1.3 \times 10^{-10}$ grams of radium per gram of wet bone. The estimated total body radium would be .75 microgram of radium compared with 1.3 micrograms estimated by external measurements (Table II). An estimate of the total body radium from the four bone samples from patient H. V. (R-13)** was .5 compared with .9 from external measurements. An estimate of the total body radium from the one bone sample from patient M. H. (R-47) was found to be 11.9 micrograms compared with 11.2 from external measurements. The total body radium estimated in patient M. L. (L-27) from bone samples was six micrograms. External measurements were not made.

It is evident that attempts to estimate total body radium from single bone samples

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* $\frac{1.3 \times 10^{-6}}{5900} = 2.2 \times 10^{-10}$ grams of radium per gram of wet bone.

** The symbol H. V. (R-13) denotes the patient's initials and the patient's number. The letter *R* signifies that this patient had received radium. The letter *L* signifies that the patient was formerly a luminous-dial worker.

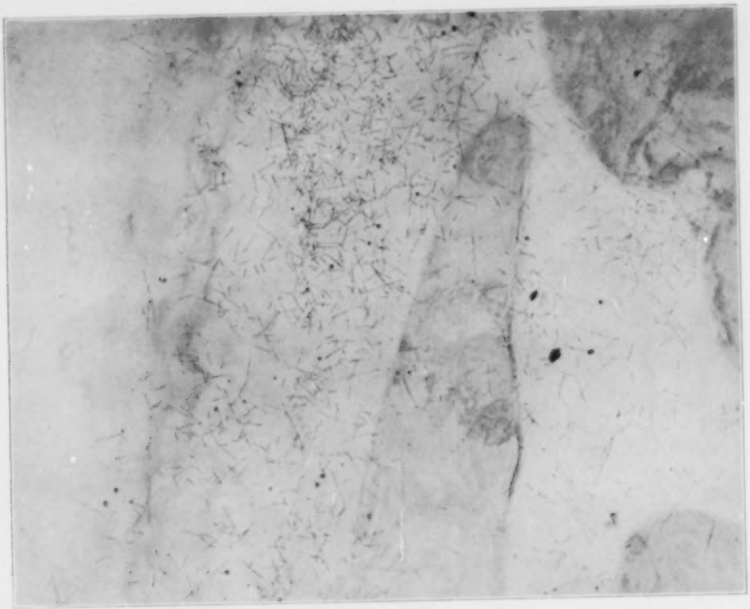

FIG. 9

Fig. 9: Detailed autoradiogram of the junction of the articular cartilage (left) with cancellous bone (right). Note the high concentration of alpha tracks at the junction and the relative absence of such in the cartilage and the darker staining atypical osseous tissue. These heavy concentrations of radium outlined the contour at the ends of the long bones and the vertebrae. (Courtesy of Dr. A. M. Brues, Division of Biological and Medical Research, Argonne National Laboratory.)

Fig. 10: Roentgenogram of a horizontal and vertical section of the fibula of patient M. K. Note the "streaked" areas that are seen in the long bones as the result of well differentiated areas of destruction in the cortex. The pointers show the areas of destruction in the vertical and horizontal planes. (Argonne National Laboratory Report, ANL 4666.)

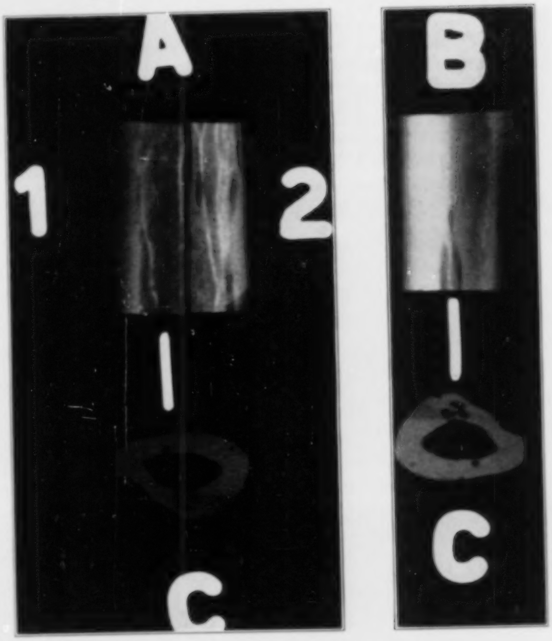

FIG. 10

are subject to many inherent errors. The concentrations in the only patient from whom extensive samples had been taken varied by a factor of ten. Estimates based on the average of the bone samples, however, were in close agreement with the estimates made by external measurements.

The small areas of marked radium concentration probably have many times more radium concentrated than the average concentration for the entire skeleton and the values given for the various bones. This is because of the inherent difficulty in being unable to

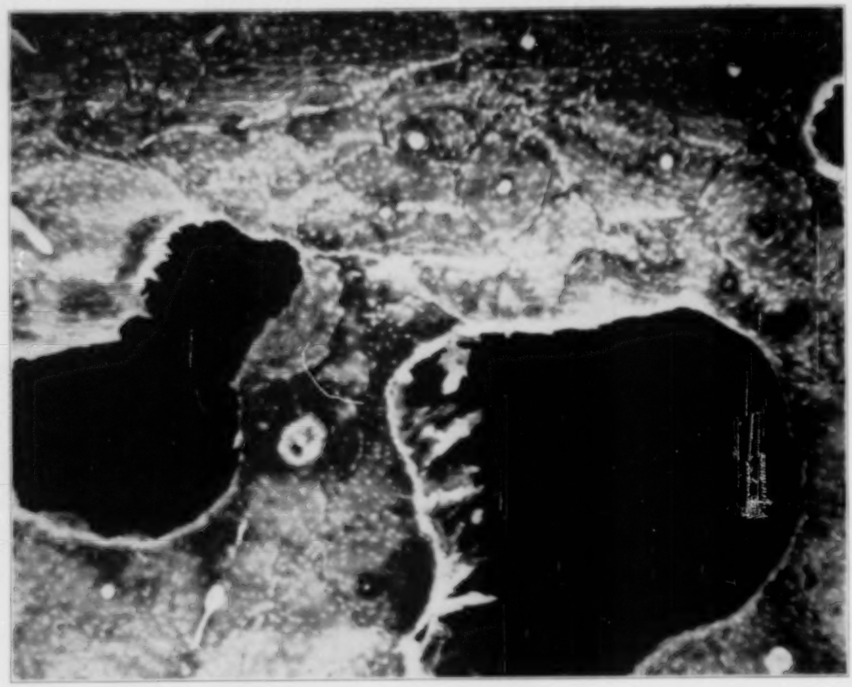

FIG. 11

Photograph of the areas of destruction seen in Fig. 10, *B*. Note that the areas of destruction which give a "streaked" appearance to the long bones are about three to six times the diameter of the Haversian systems. The central canal in between the two macroscopic areas of destruction is about one third the diameter of the Haversian system, while in the upper right corner there is a central canal that is enlarged to about two thirds the diameter of the Haversian system. (Argonne National Laboratory Report, ANL 4666.)

take bone specimens for radiochemical analysis as small as the areas involved which are usually micra in length.

It is evident that an approximation of the total body radium may be obtained by radiochemical analysis of bone specimens. Detailed autoradiography is a more accurate method for the determination of the size of the small concentrations of radium in the skeleton; quantitative autoradiography is a more accurate method for the determination of the magnitude of the concentrations; and external physical measurements give a much more reliable estimate of total body radium.

## HISTOPATHOLOGY

The histopathological changes which are most important diagnostically are: (1) the formation of an atypical osseous tissue in the trabecular spaces of cancellous bone (Figs. 3, 4, and 5) and (2) well differentiated areas of destruction in compact bone (Figs. 11, 15, 16, and 17).

Martland divided the changes in the skeleton into three stages, all of which are

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Fig. 13-A: Roentgenogram of three sections of the fibula showing the small areas of destruction. Note that these destroyed areas are either in the middle of the shaft or are near the endosteum. The autoradiogram of the sections (Fig. 13-B) shows that the areas of concentration of radium are near the periosteum.

Fig. 13-B: Autoradiogram of serial cross sections of the fibula of patient M. K. The focal areas of radium concentration are near the periosteum. None of the areas of destruction as seen by x-ray (Fig. 13-A) and the areas of radium concentration as seen by autoradiogram coincided when the x-ray and autoradiogram were superimposed. (Courtesy of Dr. A. M. Brues, Division of Biological and Medical Research, Argonne National Laboratory.)

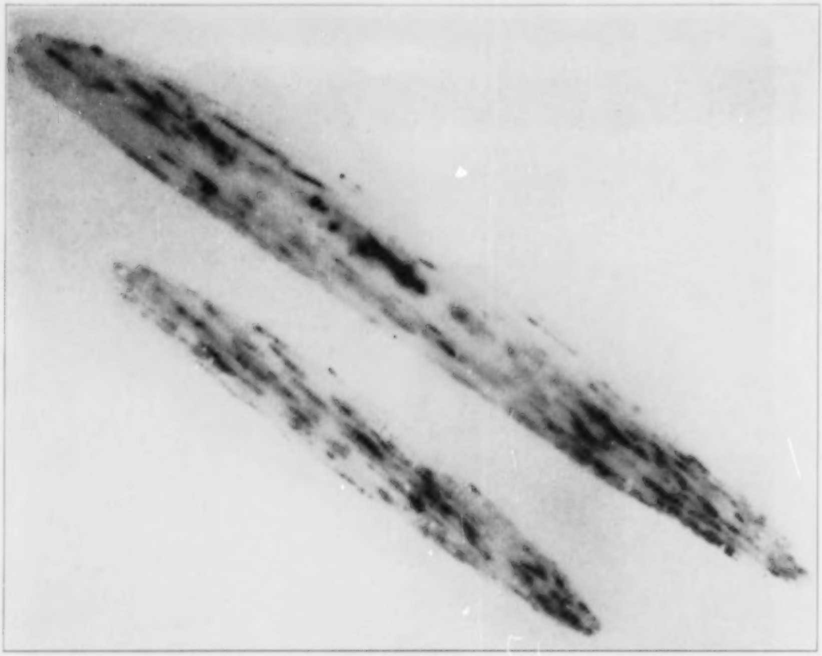

FIG. 12

Gross autoradiograms of two longitudinal sections of the cortex of a femur from patient M. K. (five-week exposure). Smaller section was taken two millimeters from the periosteum and the larger section was cut just medial to it. Areas of concentration are more frequent in the smaller section and the lower end of the larger section, which are nearer periosteum. The large area of darkening in the center of the larger section is the result, probably, of an endosteal concentration of radium, since this section was on the periphery of the marrow cavity. (Reproduced by permission from "Investigation of Radium Deposition in Human Skeleton by Gross and Detailed Autoradiography" by W. B. Looney and L. A. Woodruff. *A.M.A. Archives of Pathology*, **56**: 5, 1953.)

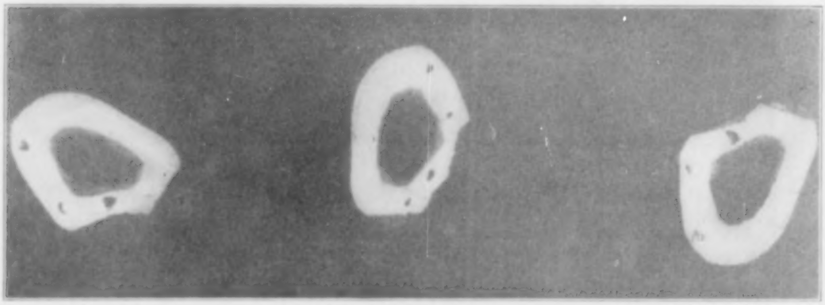

FIG. 13-A

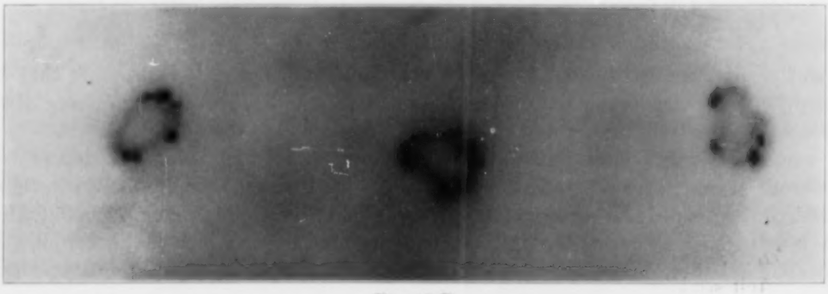

FIG. 13-B

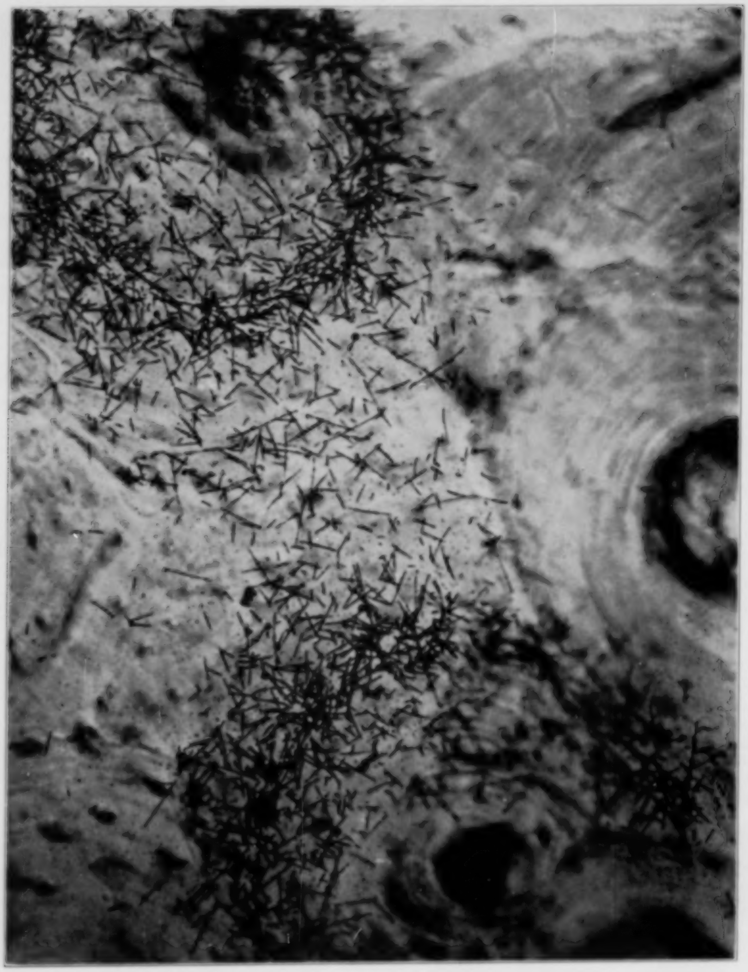

FIG. 14

Detailed autoradiogram of a cross section of cortical bone from the humeral shaft of patient M. K. (five-week exposure). Two of the small number of Haversian systems have radium concentrated in this section. The greatest concentration of radium is on two concentric lamellae in the center of the Haversian system. Alpha tracks are less dense in remainder of the two Haversian systems and interstitial lamellae between the systems. Observe that the activity suddenly falls off around these areas of concentration and that the rest of the photomicrograph is free of alpha tracks (× 207). (Reproduced by permission from "Investigation of Radium Deposition in Human Skeleton by Gross and Detailed Autoradiography" by W. B. Looney and L. A. Woodruff. *A.M.A. Archives of Pathology*, **56**: 7, 1953.)

primarily concerned with bone marrow. In Stage III, however, he did state that bone absorption and considerable decalcification did occur along with the replacement of bone marrow with non-cellular fibroblastic tissue [20].

Studies of the skeletal changes produced in animals following the deposition of radio-active elements clarify the mechanism of production of the histopathological changes that have been found in human material. Heller [4] and Bloom and Bloom [5] concluded from their studies of such bone-seeking radio-active elements as strontium, yttrium, plutonium, and radium that similar changes were produced by all of these radio-active elements.

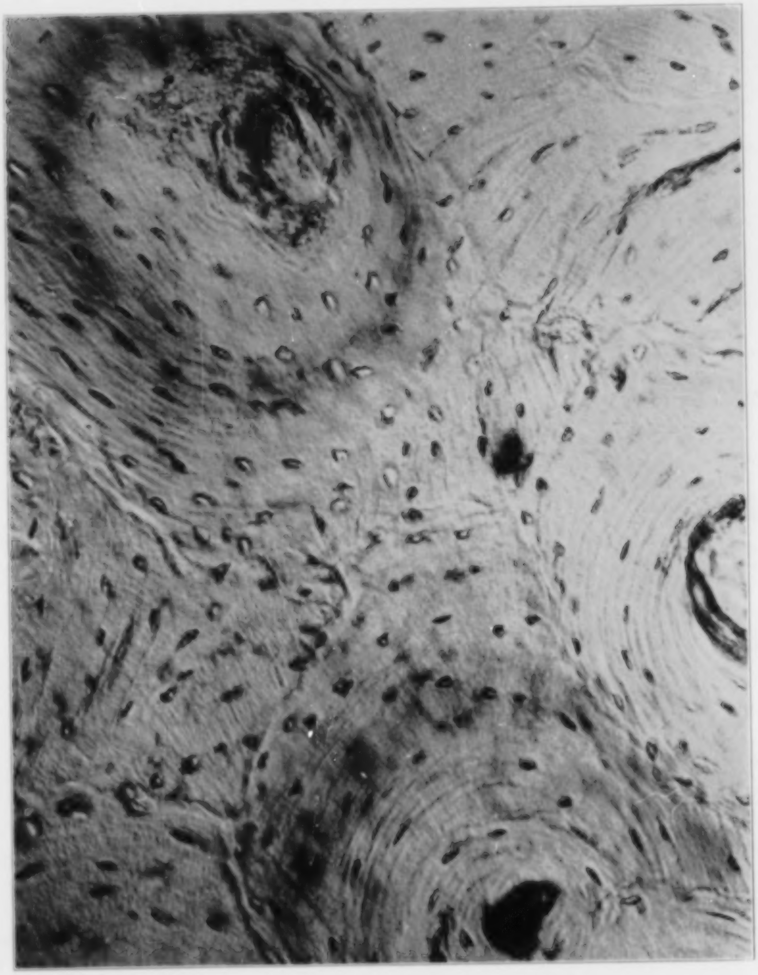

FIG. 15

Photomicrograph of bone underlying detailed autoradiogram shown in Fig. 14. Note the dark concentric rings outlining lamellae with greatest concentration of radium. Central part of Haversian system in upper left is undergoing destructive changes. This, together with Fig. 14, demonstrates how radium concentration and histopathological changes can be studied at the same time (× 218). (Reproduced by permission from "Investigation of Radium Deposition in Human Skeleton by Gross and Detailed Autoradiography" by W. B. Looney and L. A. Woodruff. *A.M.A. Archives of Pathology*, **56:** 7, 1953.)

Following radium injections in mice the most spectacular change was a dense atypical bone in the metaphysis[4,5]. This started from the proliferation of spindle cells which formed a dense fibrous tissue. Areas of calcification occurred in this fibrous tissue to form an atypical osseous tissue. It was also found to lesser degree in the shafts of the long bones and in the vertebrae. This was accompanied by the disappearance of osteoblasts, swelling and degeneration of cartilage cells, and death of most of the osteocytes. Repair began along with the destructive effects of radium. In the lower dose ranges, reversible changes occurred so that in a matter of months normal bone was found on histological examination. Larger amounts of radium produced more severe and lasting changes. The epiphyseal

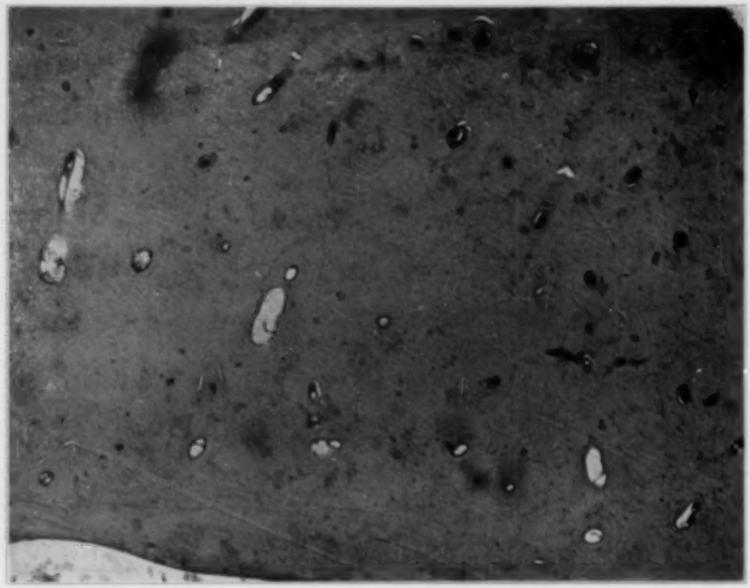

FIG. 16

Photomicrograph of the cross section of the fibula of patient M. K. Note the occlusion of the central canals with the dark staining substances. Most of the occluded canals are nearer the periosteum. Note also the variation in size of the central canals. (Courtesy of Dr. C. Howard Hatcher, Department of Orthopaedic Surgery, University of Chicago.)

cartilage varied tremendously in width, and the entire metaphysis was abnormal in appearance. The atypical osseous tissue remained in these animals at all intervals up to the termination of the experiment at five months.

The femoral shaft contained varying degrees of empty lacunae and dead osteocytes. The bones of the shaft varied from the relatively smooth contour to greater or lesser irregularities on the endosteal surface with projection into the marrow cavity [4, 5].

Histological specimens have been obtained from three luminous-dial workers and six patients who had received radium. The radio-active elements had been present in the skeleton from twelve to thirty-five years preceding biopsy and autopsy. Two luminous-dial workers and two patients who had received radium had bone tumors.

The histopathological changes were similar in certain respects to those changes found by Martland, Heller, and Bloom and Bloom. Atypical osseous tissue was present in cancellous bone. It was usually found near the articular surface of such bones as the humerus and femur, in addition to being found in the metaphyseal area (Fig. 4). The atypical osseous tissue was laid down adjacent to the trabeculae in some areas. In some areas there was hyperplasia of the trabeculae, while in others destruction of the trabeculae was present. The trabecular spaces were usually filled with an acellular fibrous tissue [17]. In general there was an absence of radio-activity in the atypical osseous tissue and acellular fibrous tissue found in the autoradiographic study (Fig. 9). In most cases, there was a prominent absence of osteocytes in the lacunae, and there was little evidence of bone regeneration.

In compact bone, the central canals showed a wide variation in size from normal to the nearly complete destruction of the entire Haversian system. A large number of the central canals were occluded with a dark staining material similar to the atypical osseous tissue in the trabecular spaces (Fig. 16). There was usually an absence of cells in the

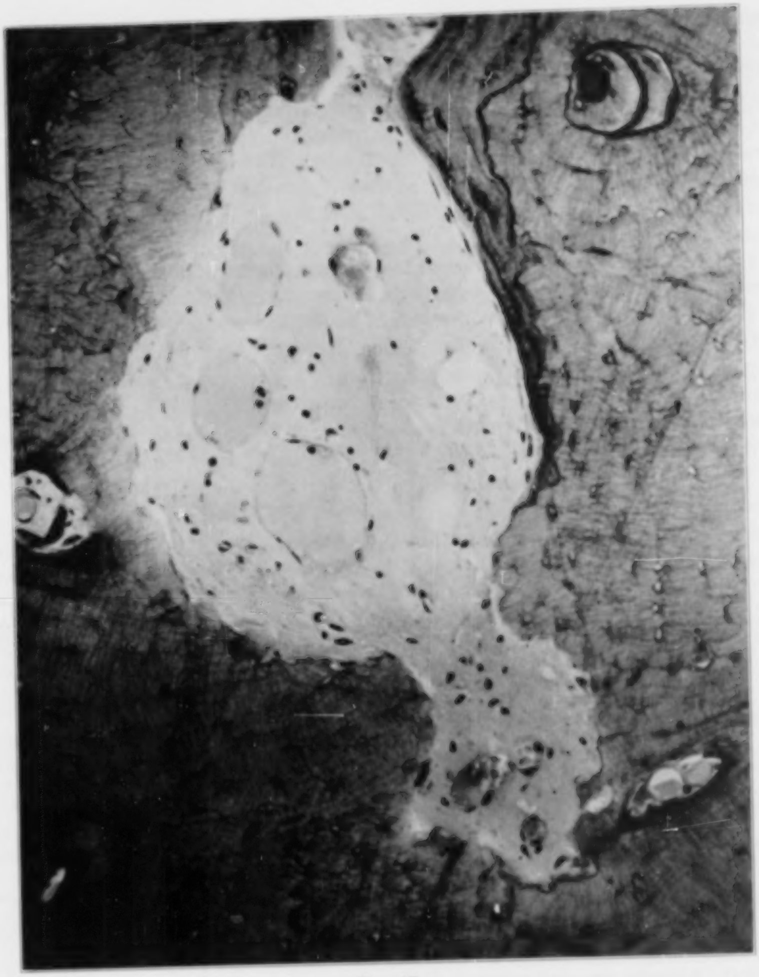

FIG. 17

Photomicrograph of a histological section from the cortex of the fibula of patient M. K. Note the central area of destruction with replacement with connective tissue. The Haversian system at the upper right has two concentric dark staining rings. This could be the result of periods of resorption followed by periods in which bone was laid down around the periphery of the central canal. (Argonne National Laboratory Report, ANL 4666.)

lacunae. Minimal evidence of bone regeneration was observed, and areas of destruction usually were replaced with fibrous connective tissue [17].

In addition to the microscopic areas of destruction, macroscopic areas of destruction have been observed in compact bone one to two millimeters in width and five to twenty millimeters in length (Figs. 10 and 11). Radium concentrations were rarely found in or around the macroscopic areas of destruction [13]. Areas of transition in which both radium concentrations and microscopic change appear together have been found rather infrequently.

It has been shown that a correlation exists between the frequency of destructive changes and the amount of radium deposited in the body. (This will be discussed in the section on Roentgenographic Changes in Part III.) It has been postulated that these macroscopic areas of destruction occur as the result of the fusion of adjacent central canals of Haversian systems undergoing destructive changes [22]. It has been further postulated that the radium had been removed from the macroscopic areas of destruction by the time the changes occurred [4]. If direct irradiation was the primary mode of production of the skeletal changes, more areas of transition should have been found in which both radium deposition and skeletal histopathological changes were present. It is evident that considerable difficulties are inherent in any attempt to reconstruct a pathological process which has been going on for twenty to thirty years from specimens taken at the termination of the process.

As a result of these observations, it is considered that radium deposited in the skeleton usually initiates a sequence of events which eventually produces pathological changes. These changes are probably the end result of many intermediate factors such as trauma, damage to blood supply, hormonal imbalance, decreased bone repair, and increased bone destruction from other causes. Evidence from the histological sections indicates that Haversian systems may undergo periods of resorption followed by periods of bone formation (Fig. 17). There was a subnormal appearance of the bone in many instances. Some of the destructive changes may be the result of the inability of bone to maintain normal repair. It is evident that the relationship between radium deposition and skeletal change is complex. It is reasonable to conclude that when the destructive effects of radium and other deleterious intermediate factors become greater than the reparative processes of the skeleton, permanent alterations occur [13].

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Mr. Melvin Runkel of the Naval Medical School and Miss Frances Fee of the Argonne National Laboratory prepared the illustrations.

## REFERENCES

1. ARNOLD, J. S.: Progress Report: Radioautography, ANL 4625. Chicago, Argonne National Laboratory, 1951.
2. AUB, J. C.; EVANS, R. D.; GALLAGHER, D. M.; and TIBBETT, D. M.: Effects of Treatment on Radium and Calcium Metabolism in the Human Body. Ann. Int. Med., **11**: 1443–1463, 1938.
3. AUB, J. C.; EVANS, R. D.; HEMPELMANN, L. H.; and MARTLAND, H. S.: The Effects of Internally Deposited Radioactive Materials in Man. Medicine, **31**: 221–239, 1952.
4. BLOOM, W.: Histopathology of Irradiation from External and Internal Sources. New York, McGraw-Hill Book Co., 1948.
5. BLOOM, M. A., and BLOOM, W.: Late Effects of Radium and Plutonium on Bone. Arch. Pathol., **47**: 494–511, 1949.

6. Brues, A. M.: Biological Hazards and Toxicity of Radioactive Isotopes. J. Clin. Invest., **28:** 1286–1296, 1949.
7. Cameron, W. H., and Viol, C. H.: Classification of the Various Methods Employed in the Internal Administration of Radium Emanation and Radium Salts. Radium, **4:** 57–68, 1915.
8. Curtiss, L. F.; Evans, R. D.; Failla, G.; Flinn, F. B.; Martland, H. S.; Paul, J. E.; Rogers, J. S.; Stephenson, C. S.; and Taylor, G. T.: Safe Handling of Radioactive Luminous Compounds. National Bureau of Standards, Handbook H 27, 1941.
9. Evans, R. D.: Radium Poisoning. II. Quantitative Determination of the Radium Content and Radium Elimination Rate of Living Persons. Am. J. Roentgenol., **37:** 368–378, 1937.
10. Hodge, P. C.: Personal communication.
11. Lisco, H.: The Standard Man. Quarterly Report, Biological and Medical Division, Argonne National Laboratory, ANL 4253, 96–101, Nov. 1948 to Feb. 1949.
12. Looney, W. B.: Radium Toxicity Program. A Progress Report of Clinical Studies on Twenty-four Patients. Argonne National Laboratory, ANL 4666, 1951.
13. Looney, W. B., and Woodruff, L. A.: Investigation of Radium Deposition in the Human Skeleton by Gross and Detailed Autoradiography. A.M.A. Arch. Pathol., **56:** 1–12, 1953.
14. Looney, W. B.: The Initial Medical and Industrial Use of Radioactive Materials. Am. J. Roentgenol., **72:** 838–848, 1954.
15. Looney, W. B.; Hasterlik, R. J.; Brues, A. M.; and Skirmont, E.: The Clinical Investigation of the Chronic Effects of Radium Salts Administered Therapeutically (1915–1930). Am. J. Roentgenol., **73:** 1006–1037, 1955.
16. Looney, W. B., and Archer, V. E.: Radium Elimination Following a Radium Accident. (To be published.)
17. Marinelli, L. D.: The Evaluation of Maximum Permissible Radium Content. (Unpublished.)
18. Marinelli, L. D.; Miller, C. F.; Gustafson, P. F.; and Rowland, R. E.: The Quantitative Determination of Gamma-Ray Emitting Elements in Living Persons. Am. J. Roentgenol., **73:** 661–671, 1955.
19. Marinelli, L. D.; Norris, W. P.; Gustafson, P. F.; and Speckman, T. W.: Transport of Radium Sulfate from the Lung and Its Elimination from the Human Body Following Single Accidental Exposures. Radiology, **61:** 903–915, 1953.
20. Martland, H. S.: The Occurrence of Malignancy in Radioactive Persons. Am. J. Cancer, **15:** 2435–2516, 1931.
21. Norris, W. P.; Speckman, T. W.; and Gustafson, P. F.: Studies of the Metabolism of Radium in Man. Am. J. Roentgenol., **73:** 785–802, 1955.
22. Phemister, D. B.: Personal communication.
23. Saubernann, S.: A Review of Radium Therapy. Seventy-ninth Annual Meeting of the British Medical Association. Lancet, **2:** 447, 1911.
24. Schlundt, H., and Failla, G.: Detection and Estimation of Radium in Living Persons. III. The Normal Elimination of Radium. Am. J. Roentgenol., **26:** 265–271, 1931.
25. Schlundt, H.; Nerancy, J. T.; and Morris, J. P.: Detection and Estimation of Radium in Living Persons. IV. Retention of Soluble Radium Salts Administered Intravenously. Am. J. Roentgenol., **30:** 515–522, 1933.
26. Seil, H. A.; Viol, C. H.; and Gordon, M. A. L.: The Elimination of Soluble Radium Salts Taken Intravenously and Per Os. Radium, **5:** 40–44, 1915; New York Med. J., **101:** 896–898, 1915.
27. Silberstein, H. E.: Radium Poisoning. A Survey of the Literature Dealing with the Toxicity and Metabolism of Absorbed Radium. Rochester, University of Rochester, A.E.C.D.—2122.

# THE REACTION OF INTERVERTEBRAL DISCS TO COMPRESSION FORCES

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During recent years, Friberg and his associates have published contributions to the clinical knowledge of low-back pain. They have been especially interested in the significance of the intervertebral disc in the low-back syndrome, its pathology and biochemistry, its physical qualities, and the frequency of structural changes with regard to different ages and professions[1-5,7-13,16-23,29,30].

The age incidence of the disease has directed our approach to the problem through various investigations. It has been demonstrated that the onset of the disease is at twenty-five to thirty years of age, that its frequency is highest at thirty to fifty years of age [1,2,3,7,12,13,30]. In 50 per cent. of the patients, there was roentgenographic evidence of disc degeneration [2,7]. Marked structural changes were sometimes found in autopsy material, even if the roentgenogram was normal. Hult found the over-all incidence of backache to be approximately 60 per cent. In 15 to 20 per cent. of the patients, pains were said to have started because of an accident; in another 20 per cent. backache began after minor trauma, often occurring while the patient was lifting or carrying heavy objects; in 60 per cent. no causative factor was reported [12,13].

In the 1930's and 1940's, it was learned that a multitude of structural changes may be found in lumbar intervertebral discs [15,27,28]. On the basis of these and other observations, there has been a growing tendency to accept disc degeneration as the pathological anatomical explanation of low-back pain [6,25]. However, we have not been able to elucidate the origin of the pain, nor have we found the pain mechanism. By the raising of the intradiscal pressure through injections into the disc, pains identical with those complained of by the patient could be produced in degenerated interspaces [7,20]; this was taken as a sign of the importance of mechanical factors. On the other hand, it could be clearly demonstrated that there was no correlation between the degree of degeneration and the clinical symptoms [10], and a great number of patients showed marked roentgenographic changes without ever having had any low-back pain. Thus, the pathological anatomical explanation itself is far from water-tight morphologically.

Many authors consider a degenerated disc to be a *locus minoris resistentiae*, which might under certain circumstances irritate nerve elements. However, it is doubtful if the disc itself contains any such sensory nerve endings. Granulation-tissue reactions, which might be a pain-producing mechanism, have been found in degenerated discs [10]. The most commonly held view, however, is that the disc may mechanically irritate surrounding sensitive tissue elements [24].

We know that structural changes occur with increasing age. From ultrastructural studies combined with biochemical analysis, it has been demonstrated that the relationship between proteins and polysaccharides is continuously changing with age; the protein part increases per unit volume while the water content decreases [11,29]. For this reason alone it must be assumed that the physical qualities also change. It might be possible that the alterations, so frequently seen macroscopically as well as microscopically, are due to a lowering of the mechanical resistance.

It is often stated that the disc is elastic. The elastic-like behavior of the intervertebral disc is dependent on the mechanical properties of the annulus and the nucleus, their geometric arrangements in space, and their geometric relationships to one another.

## THE PURPOSE OF THE INVESTIGATION

If the disc is considered as an elastic body which is undergoing biological changes, it seems important in a discussion of the pathological mechanism of low-back pain to attempt to study the physical properties of the disc in order to gain a better understanding of the cause of low-back pain [14,26,30].

In engineering, a structure is built up successively according to fundamental laws. In medicine, we often have to start with a given structure and to discover at least some of its properties among many unknown factors.

It was felt that, by studying a single intervertebral disc with regard to its reaction to simple compression forces, we might be able to see to what extent physical analysis may give us information of practical value. Therefore, the experiments to be reported were aimed at reproducing minor accidents as they occur in life. The equipment represents a compromise between technical and biological requirements; but accidents also vary from the medical point of view when they are analyzed. For this reason, only one situation was studied. A disc was loaded and was subjected to a fast-acting blow. The mechanical behavior of the disc was recorded during this procedure.

## MATERIAL

Fresh lumbar spines obtained at autopsy were used. Only a few hours had elapsed between death and the performance of the experiments. The second and the fourth lumbar discs, and in exceptional cases others also, were examined. Only normal discs were included in the experiments reported here. Therefore, after the specimens had been tested, the discs were cut through and were examined microscopically. Ruptures of the annulus were excluded as pathological; slight changes in the nucleus were accepted as normal. In the cadavera, the ages of the subjects at the time of death varied between eighteen and forty-six years. Altogether fifteen interspaces were examined.

All muscles were removed, while skeletal and ligamentous parts were carefully preserved. A disc, together with half the upper and half the

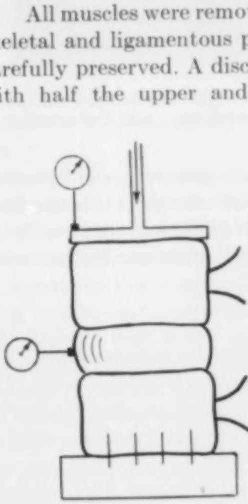

FIG. 1

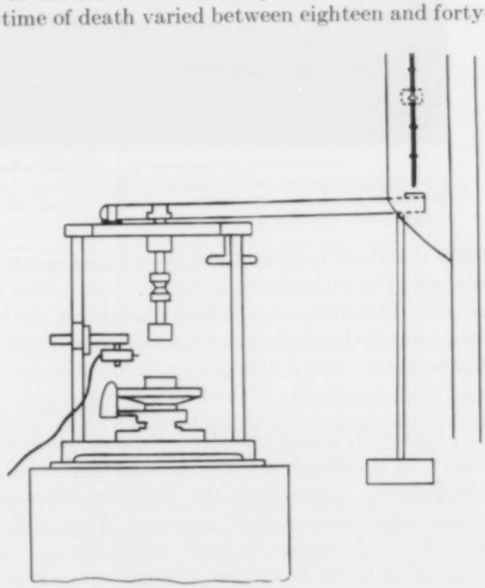

FIG. 2

Fig. 1: Diagram illustrates method of placing pick-ups. (Reproduced by permission from "New Observations on the Mechanical Behavior of Lumbar Discs" by Carl Hirsch and Alf Nachemson. *Acta Orthopaedica Scandinavica*, **23**: 259, 1954.)

Fig. 2: Diagram of compression apparatus with falling-weight attachment on the right. (Reproduced by permission from "New Observations on the Mechanical Behavior of Lumbar Discs" by Carl Hirsch and Alf Nachemson. *Acta Orthopaedica Scandinavica*, **23**: 265, 1954.)

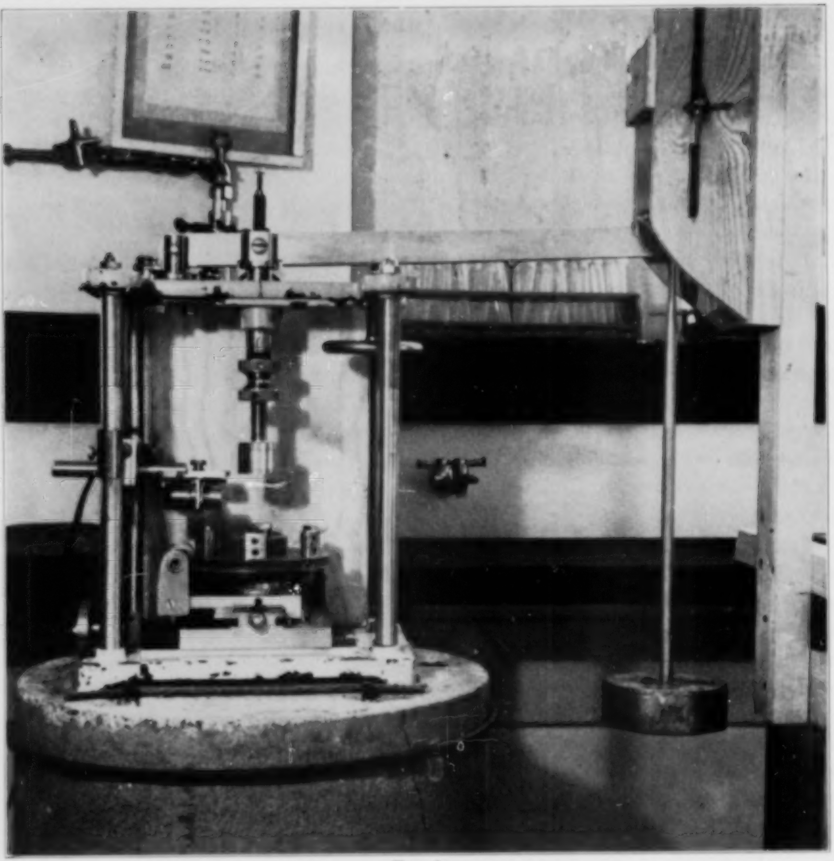

FIG. 3

View of the compression chamber. (Reproduced by permission from "New Observations on the Mechanical Behavior of Lumbar Discs" by Carl Hirsch and Alf Nachemson. *Acta Orthopaedica Scandinavica*, **23**: 264, 1954.)

lower vertebral body and the corresponding intervertebral joints, was removed by means of a saw. The cut surfaces of the vertebral bodies were leveled with a file so as to make them parallel. The specimen was then placed on a flat base, made absolutely horizontal with the aid of a spirit level. Roentgenograms were made of all specimens before any further treatment.

## EXPERIMENTAL DEVICES

Figures 1, 2, and 3 illustrate the manner in which the experiments were arranged. The discs with the attached vertebrae were preloaded with weights acting through a lever. The deformations occurring in the disc were recorded on a Philip's direct-reading measuring bridge using displacement pick-ups. When stability had been obtained, which could be seen on the instruments (generally after five minutes), a weight of one kilogram was dropped on to the lever from a height varying between 0.10 and 0.50 meter. The deformations occurring in the disc were graphed by means of a Kelvin-Hughes type II-A recorder. The measuring bridge used in these experiments, the displacement pick-up, and the recorder were calibrated [9]. The errors of measurement were less than 5 per cent.

## RESULTS

The degree of compression of the disc registered from increasing statically applied loads can be seen in Figure 4. The compression also caused the disc to bulge circumferentially. The measurement of this deformation at one point anteriorly is given in Figure 5. It is striking how little the discs are changed in their entire circumference.

The deformation, however, depends not only upon the magnitude of the load but also upon the duration of loading. The deflection which takes place as a given load is applied steadily for some minutes is shown in Figure 6. The curve approaches a certain maximum, and a relatively stable condition is attained after five to ten minutes. The type or shape of the curve is not dependent upon the magnitude of the statically applied load. With loads up to 130 kilograms (the maximum load applied in the experiments), most of the deformation occurred during the first thirty seconds. Thereafter, the change in form proceeded slowly. No absolute equilibrium was reached even though the experiments were continued for hours.

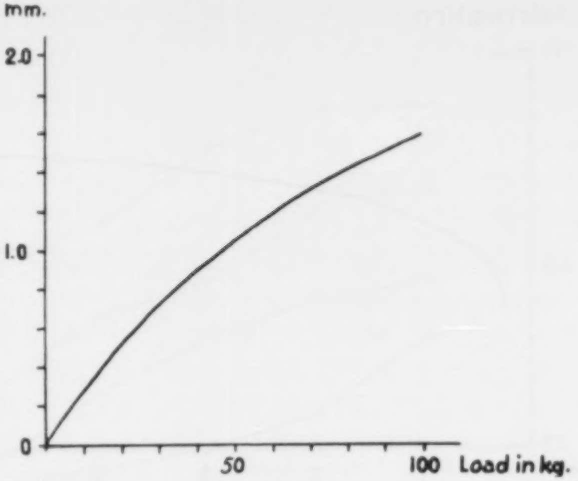

FIG. 4

The degree of compression of a normal disc (fourth lumbar) is registered from increasing statically applied loads.

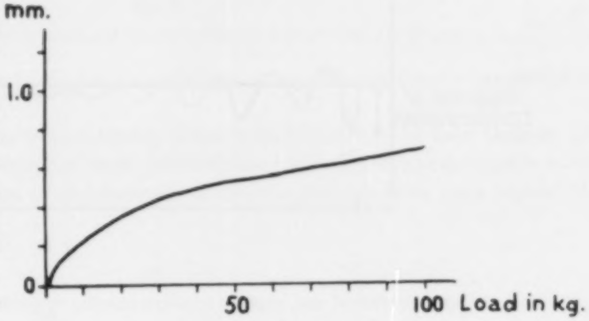

FIG. 5

The measurement of the deformation at one point anteriorly is shown (normal disc, fourth lumbar).

If an intervertebral disc is exposed to a dynamically applied force, it may begin to vibrate (Fig. 7). A number of vibrations will occur in less than one second and then die out. The amplitude of these vibrations is greatest during the first hundredths of a second. Hence, if a load is suddenly applied to a disc, the disc is at first compressed and begins to expand in the opposite direction. During this phase its width exceeds that in its original position. In other words, if there is a certain distance between two vertebrae, a sudden blow will first cause the vertebrae to draw closer due to the compression and at the same time the disc will bulge circumferentially. Fractions of a second later, the vertebrae withdraw from one another even further than the normal distance. At the same time the margins of the disc recede inward. Gradually these vibrations die out. The intervertebral disc has therefore acted as a shock absorber, damping the oscillations.

The analysis of the vibrations of an intervertebral disc following dynamically applied loads is quite complex and involves many variables. One of these, the amplitude of the vibrations, will be discussed in this paper.

It appears from the foregoing that an intervertebral disc reacts in two quantitatively different ways to compression forces. To a statically applied force, the disc responds

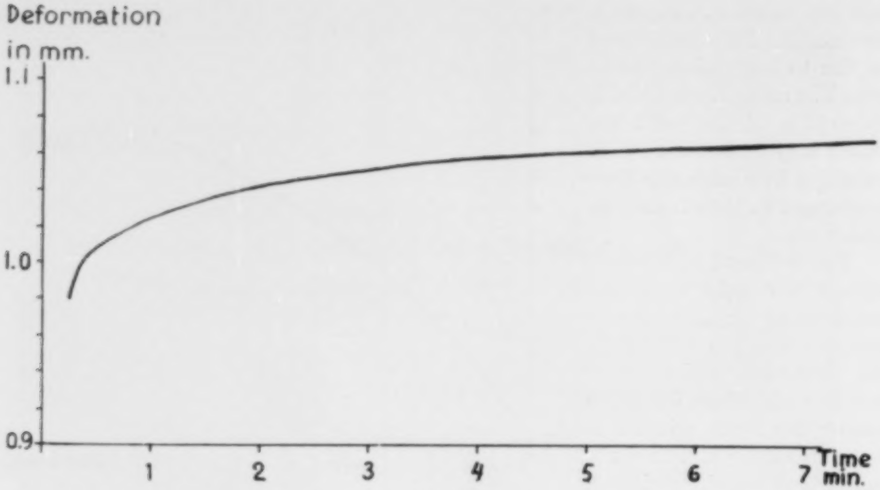

FIG. 6

Compression-time curve. Deflection takes place as a given load (100 kilograms) is applied steadily.

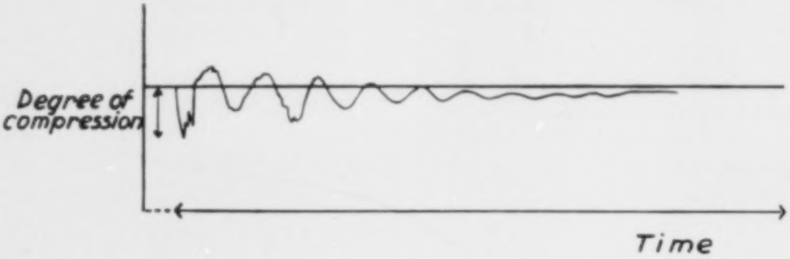

FIG. 7

An intervertebral disc, exposed to a dynamically applied load, begins to vibrate.

with a slow change of form. A force of rapid action, on the other hand, produces rapid alternating changes in form. The reaction to a statically applied load takes place in the course of minutes, while the response to the dynamic load occurs within fractions of a second.

Thus, generally speaking, a disc has mechanical properties similar to many other elastic or semi-elastic systems.

The magnitude of the initial shock compression was read from the instruments. Figure 8 shows the initial shock compression produced by one kilogram falling 0.10 to 0.50 meter. The preload varied between 10 and 130 kilograms. It can be seen from the graph that the amplitude increased with increasing falling height for any one preload. For a constant falling height, the initial shock compression decreased if the preload was increased.

In the series here recorded the measurements were made on the same disc. In Figure 9 the initial shock compression has been correlated with the preload. Up to 70 kilograms preload, the initial shock compression decreased rapidly. The rate of the decrease was less as the load was further increased.

The variations in amplitude demonstrable in the experiments are partly due to the disc being compressed when the preload increases and partly due to the fact that the greater the preload the more energy input will be required to displace the preload.

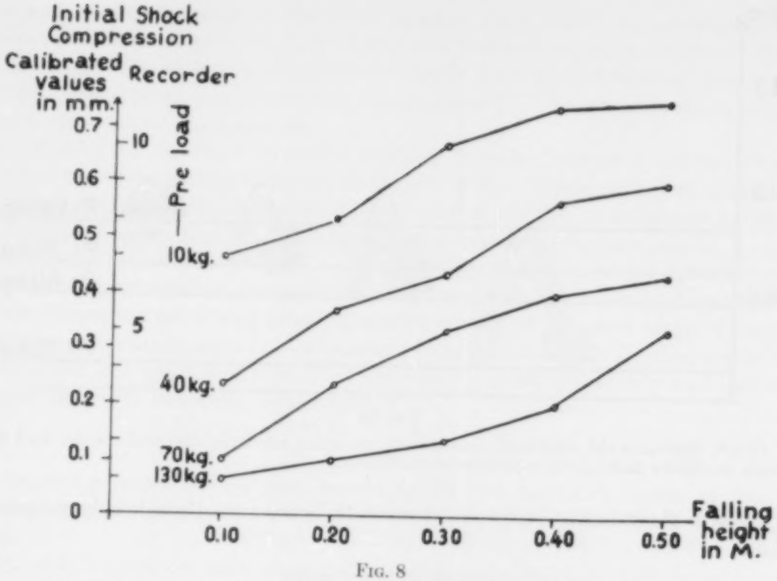

FIG. 8
Initial shock compression produced by one kilogram falling 0.10 to 0.50 meter.

The question now arises whether any conclusions of clinical significance can be drawn from these experiments.

From a study of the compression curves (Figs. 4 and 5), it can be seen that, as the load is increased, the disc approaches closer to its elastic limit. If a dynamic load is added to this, the added deformation in the form of vibrations may at their peak exceed the

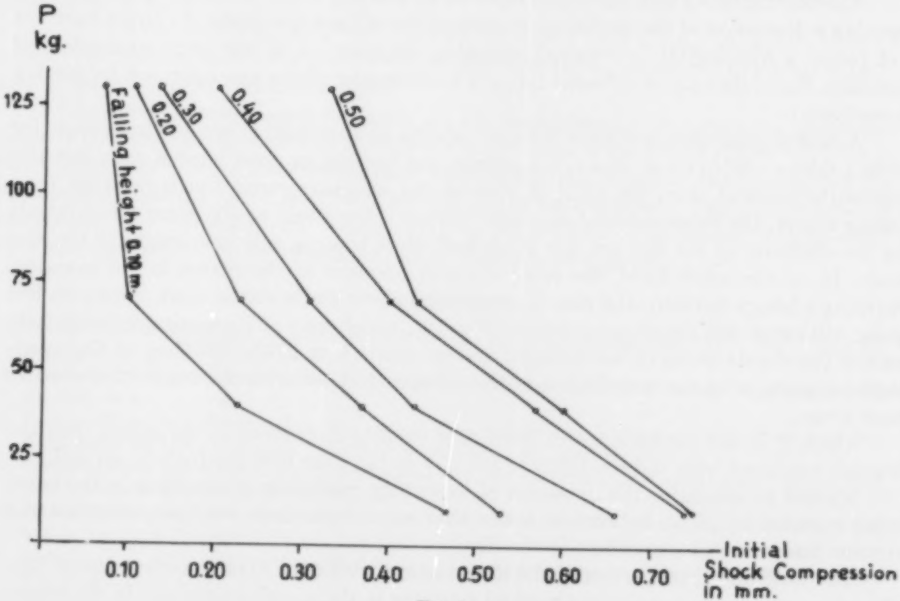

FIG. 9
Initial shock compression correlated with the preload.

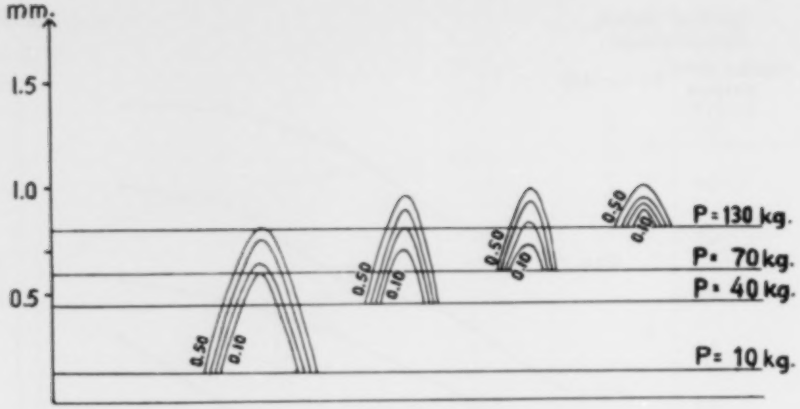

FIG. 10

Graph illustrates the additional deformation occurring when the disc under static load is made to vibrate under given experimental conditions.

elastic limit of the annulus or its attachment to bone, even though only momentarily (Fig. 10).

## CLINICAL DISCUSSION

Every orthopaedic surgeon encounters workmen who complain that while they were carrying a heavy object something happened to the burden. There was an extra strain followed by sudden severe pain in the back. The patient often explains that he had to protect himself by a violent muscle action. In most countries, these apparently insignificant injuries are not recognized by the insurance companies as cases for compensation. To the patient this seems an injustice.

The experiments which have been reported in this paper aim at changing our view and opening a discussion of the pathological mechanism of back traumata. Since we have not yet found a histological or neurophysiological explanation of the pain mechanism of lumbago, the evaluation of different types of stresses may offer a new approach for further investigation.

A loaded spine does not have the same ability as an unloaded one to compensate for even a minor sudden extra strain. If a person, not bearing an extra burden, falls down (a legitimate accident from the point of view of the insurance carrier) or if he is hit by a falling object, the intervertebral disc will "absorb" the strain easily, since the demands on the elasticity of the disc are less in an individual bearing only the weight of his own body. If, on the other hand, the spine is under pressure (if the person is, for example, carrying a heavy burden), the disc is compressed closer to its elastic limit. A sudden impulse will cause additional compression (Fig. 10), which may at its maximum amplitude exceed the elastic limits of the collagen system somewhere in the annulus, of the cartilaginous plate, or of the attachment of the collagen to bone with the result that rupture may occur.

Thus, it is not the violence in itself that decides the extent of the injury, but the trauma combined with the condition of the disc at the time that the force is applied.

Viewed in this light, the sensation of something rupturing or snapping in the back, often reported by patients, may be a sign that some stress limit has been exceeded and rupture has occurred somewhere in the disc.

The mechanical properties of the discs change with age. Above thirty years of age, almost everyone has more or less marked ruptures in the annulus structure in the lowest interspaces. From thirty to fifty years of age, there are degenerative changes in both the annulus and nucleus in most of the lower lumbar discs, which presumably alter the mechanical properties, decreasing their ability to withstand mechanical forces. After this period of life, the interspace is changed into a more dense fibrous material protected by osteophytes and surrounding connective tissue elements. Perhaps as a result of this it becomes better able to stand stresses.

By adopting a biomechanical way of thinking, it seems possible to explain why low-back pain is most frequent at thirty to fifty years of age. However, we do not know in which way and to what extent the elastic behavior of the disc is influenced by the biological process of aging. Further experimental studies may clarify this point.

The present investigation suggests the possibility of determining loads that can be tolerated by an intervertebral disc under varying circumstances. By extending the experimental conditions and employing greater forces we could find the upper limits of tolerance. By analyzing traumata in actual cases we might be able to calculate the magnitude of the forces involved. We could then reproduce the conditions experimentally and this would allow us to determine definitely what happens.

## SUMMARY

1. Assuming intervertebral disc lesions to be the causative factor of low-back pain, our present knowledge does not allow us to explain the pathological mechanism involved.

2. Since at least 40 per cent. of all patients with backache claim that the pain started because the back was subjected to extra strain, it is suggested that biomechanical studies may give a new approach for pathological and mechanical discussions.

3. An experimental approach has been adopted by which the mechanical responses of intervertebral discs can be recorded with a high degree of accuracy.

4. Two quantitatively different responses of the disc have been described. The reaction to a statically applied load takes place in the course of minutes, while the response to the dynamic load occurs within fractions of a second. The latter is characterized by vibrations in the disc.

5. Vibrations were registered with a disc under steady load. Even if a disc has reached a static equilibrium, additional rapid forces can increase the deformations to a great extent, even if these forces are relatively small.

6. Apparently insignificant traumata are not recognized by the insurance companies in many countries as cases for compensation. On the basis of the observations recorded in the experiments, it is not the violence itself that decides the extent of the damage but the trauma combined with the condition of the disc at the time of injury. The more the disc is compressed, the less additional trauma may be required to cause lesions. Degenerated discs may, under certain circumstances, show a decreased tolerance to stress.

## REFERENCES

1. Friberg, Sten: Low Back and Sciatic Pain Caused by Intervertebral Disc Herniation. Acta Chir. Scandinavica, **85:** Supplementum 64, 1941.
2. Friberg, Sten: Anatomical Studies on Lumbar Disc Degeneration. Acta Orthop. Scandinavica, **17:** 224–230, 1948.
3. Friberg, Sten, and Hirsch, Carl: On Late Results of Operative Treatment for Intervertebral Disc Prolapses in the Lumbar Region. Acta Chir. Scandinavica, **93:** 161–168, 1946.
4. Friberg, Sten, and Hirsch, Carl: Anatomical and Clinical Studies on Lumbar Disc Degeneration. Acta Orthop. Scandinavica, **19:** 222–242, 1949.
5. Friberg, Sten, and Hult, Lennart: Comparative Study of Abrodil Myelogram and Operative Findings in Low Back Pain and Sciatica. Acta Orthop. Scandinavica, **20:** 303–314, 1953.
6. Hansen, H.-J.: A Pathologic-Anatomical Study on Disc Degeneration in Dogs. Acta Orthop. Scandinavica, Supplementum 11, 1952.
7. Hirsch, Carl: An Attempt to Diagnose the Level of a Disc Lesion Clinically by Disc Puncture. Acta Orthop. Scandinavica, **18:** 132–140, 1949.

8. Hirsch, Carl: Studies on the Mechanism of Low Back Pain. Acta Orthop. Scandinavica, **20:** 261–274, 1951.
9. Hirsch, Carl, and Nachemson, Alf: New Observations on the Mechanical Behavior of Lumbar Discs. Acta Orthop. Scandinavica, **23:** 254–283, 1954.
10. Hirsch, Carl, and Schajowicz, Fritz: Structural Changes in the Lumbar Annulus Fibrosus. Acta Orthop. Scandinavica, **22:** 184–231, 1952.
11. Hirsch, Carl; Paulson, S.; Sylven, B.; and Snellman, O.: Biophysical and Physiological Investigation on Cartilage and Other Mesenchymal Tissues. IV. Characteristics of Human Nuclei Pulposi During Aging. Acta Orthop. Scandinavica **22:** 175–183, 1952.
12. Hult, Lennart: The Munkfors Investigation. Acta Orthop. Scandinavica, **23:** Supplementum 16, 1954.
13. Hult, Lennart: Cervical, Dorsal and Lumbar Spinal Syndromes. Acta Orthop. Scandinavica, **23:** Supplementum 17, 1954.
14. Ingelmark, Bo E., und Ekholm, Ragnar: Über die Kompressibilität der Intervertebralscheiben. Eine experimentelle Untersuchung über die Intervertebralscheibe zwischen dem dritten und vierten Lendenwirbel beim Menschen. Acta Soc. Med. Upsaliensis, **57:** 202–217, 1952.
15. Junghanns, H.: Die Pathologie der Wirbelsaule. *In* Handbuch der speziellen pathologischen Anatomie und Histologie von O. Lubarsch und F. Henke. Band 9, Teil 4. Berlin, Julius Springer, 1939.
16. Lindblom, Knut: Eine anatomische Studie über lumbale Zwischenwirbelscheibenprotrusionen und Zwischenwirbelscheibenbrüche in die Foramina Intervertebralia hinein. Acta Radiol., **22:** 711–721, 1941.
17. Lindblom, Knut: Lumbala diskprolapser vid foramina intervertebralia. Nordisk Med., **16:** 3597–3602, 1942.
18. Lindblom, Knut: Protrusions of Disks and Nerve Compression in the Lumbar Region. Acta Radiol., **25:** 195–212, 1944.
19. Lindblom, Knut: The Subarachnoid Spaces of the Root Sheaths in the Lumbar Region. Acta Radiol., **30:** 419–426, 1948.
20. Lindblom, Knut: Technique and Results in Myeolography and Disc Puncture. Acta Radiol., **34:** 321–330, 1950.
21. Lindblom, Knut: Experimental Ruptures of Intervertebral Discs in Rats' Tails. J. Bone and Joint Surg., **34-A:** 123–128, Jan. 1952.
22. Lindblom, Knut, and Hultquist, G.: Absorption of Protruded Disc Tissue. J. Bone and Joint Surg., **32-A:** 557–560, July 1950.
23. Lindblom, Knut, and Rexed, Bror: Spinal Nerve Injury in Dorso-Lateral Protrusions of Lumbar Discs. J. Neurosurg., **5:** 413–432, 1950.
24. Lindemann, K., and Kuhlendahl, H.: Die Erkrankungen der Wirbelsäule. Stuttgart, Ferdinand Enke, 1953.
25. Olsson, E.: On Disc Protrusion in Dogs. Acta Orthop. Scandinavica, **21:** Supplementum 8, 1951.
26. Petter, C. K.: Methods of Measuring the Pressure of the Intervertebral Disc. J. Bone and Joint Surg., **15:** 365–368, Apr. 1933.
27. Schmorl, G.: Über Knorpelknoten an der Hinterfläche der Wirbelbandscheiben. Fortsch. a. d. Geb. d. Röntgenstr., **40:** 629–634, 1929.
28. Schmorl, G., und Junghanns, H.: Die gesunde und kranke Wirbelsäule in Röntgenbild und Klinik. Stuttgart, Georg Thieme, 1953.
29. Sylven, Bengt; Paulson, Sten; Hirsch, Carl; and Snellman, Olle: Biophysical and Physiological Investigations on Cartilage and Other Mesenchymal Tissues. II. The Ultrastructure of Bovine and Human Nuclei Pulposi. J. Bone and Joint Surg., **33-A:** 333–340, Apr. 1951.
30. Unander-Scharin, L.: On Low Back Pain. With Special Reference to the Value of Operative Treatment. Acta Orthop. Scandinavica, **19:** Supplementum 5, 1950.

# AN EXPERIMENTAL COMPARISON OF FREEZE-DRIED AND FROZEN CORTICAL BONE-GRAFT HEALING

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## INTRODUCTION

A comparison of fresh autogenous, frozen, and freeze-dried bone-graft healing in the dog has been previously reported by Kreuz, Hyatt, Turner, and Bassett from work done in the Naval Medical Research Institute [2]. The results indicated that freeze-dried and frozen cortical bone grafts healed in the same manner as fresh autogenous grafts, but at a slightly slower rate, and that freeze-dried grafts seemed to be incorporated slightly more rapidly in the early stages than the frozen grafts. Since the initial report, freeze-drying techniques have been improved, with resultant improvement in freeze-dried bone-graft healing [1].

The evaluation of freeze-dried and frozen bone-graft healing presented here consists of a comparison of the control grafts in an experiment on cathode-ray sterilization of frozen and freeze-dried bone grafts [3].

## METHOD OF GRAFT PROCUREMENT, TREATMENT, AND STORAGE

On several occasions large numbers of rectangular cortical-bone grafts were procured

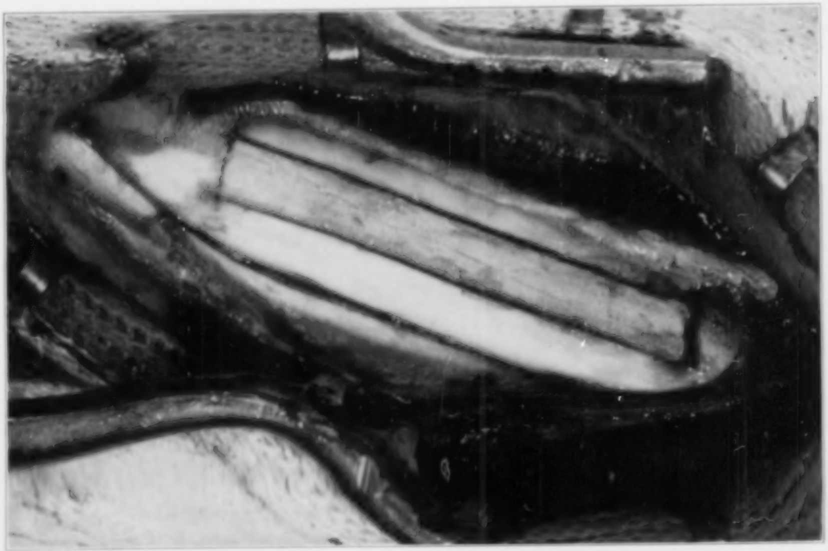

FIG. 1

The operative procedure consisted in bilateral implantation of cortical inlay grafts in the radii of adult mongrel dogs. Sterile irradiated freeze-dried grafts were implanted on the right with freeze-dried non-irradiated controls on the left in one series of dogs. In another group of dogs frozen irradiated grafts and control grafts were implanted. This provided experimental material suitable for two separate purposes. By comparing the irradiated and control graft of each animal, observations were made concerning the effect of cathode irradiation on graft healing; that study is to be presented separately. The large number of non-irradiated control grafts provided a means of determining the effect of the method of preservation (freeze-drying or freezing) on graft healing. The present paper deals with the latter study.

TABLE I

AVERAGE NUMERICAL VALUES (0 TO 4) OBSERVED FOR VARIOUS ASPECTS OF GRAFT HEALING

| Freeze-Dried Grafts (Not Irradiated) | | | | | | | | Frozen Grafts (Not Irradiated) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dog No. | Storage Time (*Days*) | Stage of Healing (*Days*) | | Amount of Residual Graft (*Days*) | | Perivascular New Bone (*Days*) | | Dog No. | Stage of Healing (*Days*) | Implantation Time (*Days*) | | Amount of Residual Graft (*Days*) | | Perivascular New Bone (*Days*) | |
| | | 35 | 90 | 35 | 90 | 35 | 90 | | | 35 | 90 | 35 | 90 | 35 | 90 |
| OC2-L | 39 | | 3½ | | ½ | | 2½ | OC8-L | 50 | | 3 | | 2 | | 2½ |
| OC3-L | 44 | | 2½ | | 2 | | 2 | OC11-L | 31 | | 2½ | | 2½ | | 1½ |
| OC4-L | 45 | | 2½ | | 1½ | | 2 | OC12-L | 38 | | 1½ | | 3½ | | 1 |
| OC5-L | 53 | | 2½ | | 1½ | | 2 | OC29-L | 106 | | 2½ | | 3 | | 1½ |
| OC6-L | 56 | | 2 | | 2 | | 2½ | OC30-L | 106 | | 2½ | | 3 | | 1½ |
| OC19-L | 100 | | 2½ | | 2 | | 2½ | OC41-L | 26 | | 2½ | | 2 | | 2 |
| OC32-L | 143 | | 2½ | | ½ | | 3 | OC42-L | 27 | | 2 | | 3 | | 1½ |
| OC33-L | 143 | | 2½ | | 2 | | 2 | OC43-L | 29 | | 2 | | 3½ | | 1 |
| OC36-L | 150 | | 2½ | | ½ | | 3½ | OC45-L | 55 | | 2½ | | 3½ | | 1½ |
| OC37-L | 150 | | 3 | | ½ | | 3½ | OC46-L | 55 | | 2½ | | 3½ | | 1½ |
| Totals | | | 28 | | 13 | | 25½ | Totals | | | 23½ | | 29½ | | 15½ |
| OC20-L | 101 | 2 | | 3½ | | 1 | | OC21-L | 95 | 1 | | 4 | | ½ | |
| OC23-L | 108 | 2 | | 3 | | 1 | | OC22-L | 90 | 1 | | 4 | | 0 | |
| OC25-L | 108 | 2½ | | 3½ | | 1 | | OC24-L | 92 | 1 | | 3½ | | ½ | |
| OC27-L | 115 | 1½ | | 3½ | | 1 | | OC26-L | 61 | 1½ | | 3½ | | 1 | |
| OC34-L | 143 | 2½ | | 2½ | | 2 | | OC28-L | 70 | 1½ | | 3½ | | ½ | |
| Totals | | 10½ | | 16 | | 6 | | Totals | | 6 | | 18½ | | 2½ | |

Storage Time of Grafts Prior to Implantation

Average for 90-day freeze-dried grafts = 92.3 days—maximum 150 days, minimum 39 days.
Average for 90-day frozen grafts = 52.3 days—maximum 106 days, minimum 26 days.
Average for 35-day freeze-dried grafts = 115.0 days—maximum 143 days, minimum 101 days.
Average for 35-day frozen grafts = 80.6 days—maximum 95 days, minimum 61 days.

from adult mongrel dogs at sterile autopsy. Each group of grafts was divided into two equal parts, and all grafts in each part were preserved in the same manner, by freeze-drying or by freezing.

Freeze-drying was carried out in a commercial machine for approximately two weeks. After removal from the freeze-drier, the grafts were placed in individual vacuum-sealed glass tubes and were, thereafter, stored on the shelf at room temperature.

The frozen grafts were stored in individual rubber-stoppered glass tubes and were kept at −78 degrees centigrade. The original plan required equal storage periods for groups of frozen and freeze-dried grafts, but on two occasions technical failure resulted in thawing of the frozen grafts. These grafts were replaced because of possible damage incurred by thawing. This resulted in longer storage periods for the freeze-dried grafts, which may be construed as being a possible advantage for the frozen bone (Table I).

## METHOD OF IMPLANTATION

Bilateral homogenous cortical inlay grafts measuring approximately 0.5 by four centimeters were implanted in the radii of forty-seven adult mongrel dogs; controls of

TABLE II-A

EVALUATION OF FROZEN AS COMPARED WITH FREEZE-DRIED GRAFTS *
(Using totals listed in Table I)

35-Day Grafts
Based on Five Frozen and Five Freeze-Dried Grafts

| | Stage of Healing | Perivascular New Bone | Amount of Residual Graft | Total Amount of Graft Present in 5 Grafts Originally (4 for each graft) | Amount of Graft Eliminated |
|---|---|---|---|---|---|
| F (frozen) grafts | 6 | 2½ | 18½ | 20 | 1½ |
| FD (freeze-dried) grafts | 10½ | 6 | 16 | 20 | 4 |
| Ratio of performance F/FD | 57.1% | 41.7% | | | 37.5% |
| Over-all ratio of F/FD performance (average of above ratio) | | | | | 45.4%<br>or 1 to 2.2 |

Therefore, from an over-all standpoint freeze-dried grafts performed better than frozen grafts at 35 days by a ratio of 2.2 to 1.

* Tables II-A and II-B list and compare the totals obtained in Table I. The amount of the graft eliminated was obtained by subtracting the total amount of residual grafts in each series of dogs from the total possible amount of grafts (twenty in the five-dog series and forty in the ten-dog series). The results indicate definite superiority of the freeze-dried grafts which was more marked at thirty-five days than it was at ninety days.

TABLE II-B

EVALUATION OF FROZEN AS COMPARED WITH FREEZE-DRIED GRAFTS
(Using totals listed in Table I)

90-Day Grafts
Based on Ten Frozen and Ten Freeze-Dried Grafts

| | Stage of Healing | Perivascular New Bone | Amount of Residual Graft | Total Amount of Graft Present in 10 Grafts Originally | Amount of Graft Eliminated |
|---|---|---|---|---|---|
| F (frozen) grafts | 23½ | 15½ | 29½ | 40 | 10½ |
| FD (freeze-dried) grafts | 28 | 25½ | 13 | 40 | 27 |
| Ratio of performance F/FD | 84% | 60.8% | | | 39% |
| Over-all ratio of F/FD performance (average of above ratios) | | | | | 61.3%<br>or 1 to 1.63 |

Therefore, from an over-all standpoint freeze-dried grafts performed better than frozen grafts at 90 days by a ratio of 1.63 to 1.

freeze-dried or frozen grafts were used on the left side and high-voltage cathode-irradiated freeze-dried or frozen grafts were used on the right side (Fig. 1).

In previous experiments it was found that the optimum time for observing initial and maximal bone revascularization was approximately thirty-five and ninety days after implantation. Therefore, all animals were sacrificed and autopsy was done at either thirty-five or ninety days [2]. In twenty-one dogs frozen control grafts and irradiated grafts were implanted, while in another group of twenty-six dogs, freeze-dried control grafts and irradiated grafts were implanted. Three animals died prematurely of pneumonia, and one animal each died of encephalitis, anaesthesia, or dogfight, so that there were twenty-three animals with freeze-dried grafts and eighteen with frozen grafts for study.

## METHOD OF INTERPRETATION

Longitudinal x-rays were made of each foreleg at the time of autopsy in order to locate the grafts accurately. By superimposing the x-ray on the foreleg, a 0.5 to one centi-

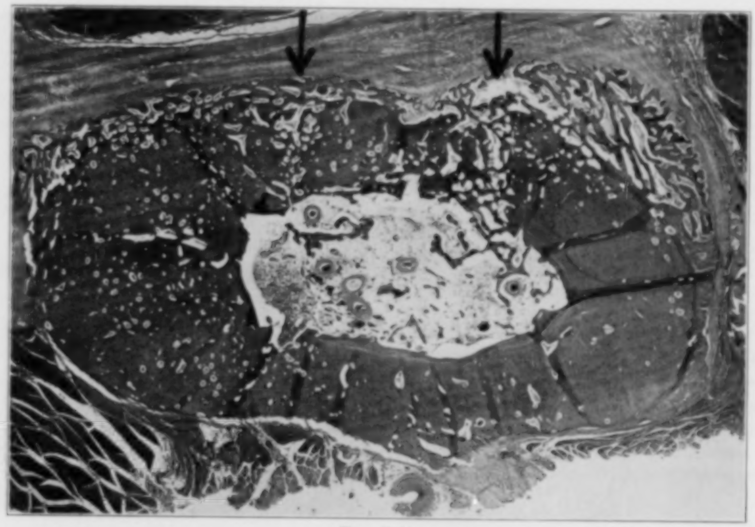

FIG. 2-A

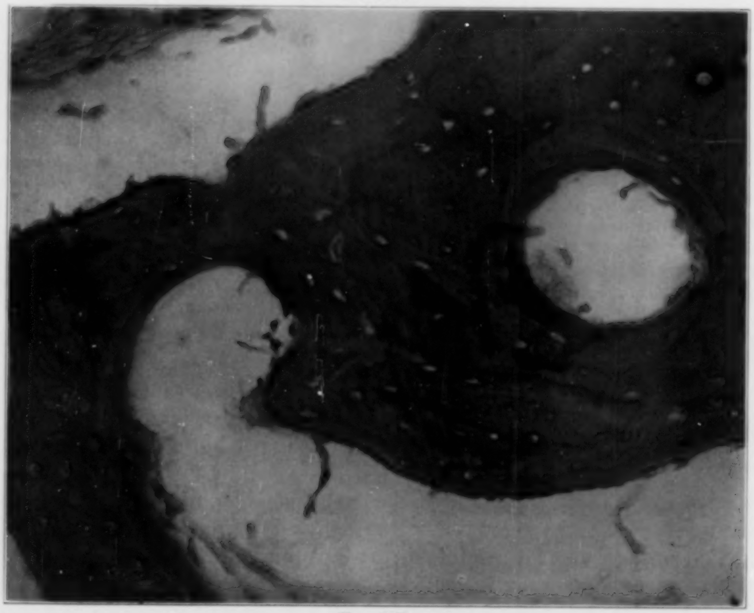

FIG. 2-B

Photomicrographs of graft OC23-L represent the average picture of freeze-dried graft healing at thirty-five days postoperative. Revascularization and, to a lesser degree, perivascular new-bone formation are in progress, resulting in the elimination of approximately 25 per cent. of the graft. The graft lies between the arrows in the low-power view (Fig. 2-A) (× 8). The high-power view (Fig. 2-B) (× 132) demonstrates revascularization, as well as perivascular new-bone formation and reactive new-bone formation along the margin of the graft.

meter cross-section was taken from the central area of each graft. These sections included soft tissue of the foreleg as well as part of the radius with its graft. These blocks were fixed in buffered formalin solution and were subjected to electrolytic decalcification. Routine hematoxylin and eosin sections of ten-micron thickness were then prepared.

Microscopic evaluations of these sections were made independently by three investi-

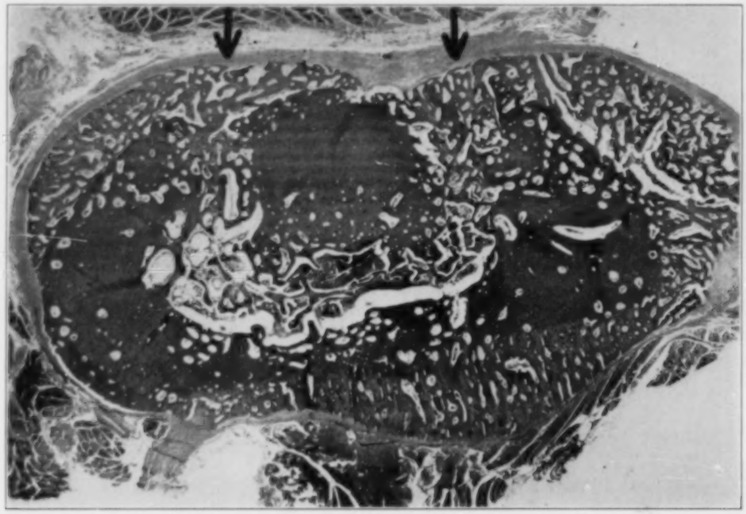

Fig. 3-A

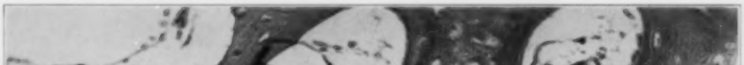

Fig. 3-B

Photomicrographs of a thirty-day frozen graft (OC26-L). The graft lies between the arrows in the low-power view (× 8). It represents the most advanced graft in a series of five frozen grafts, but it is definitely retarded in rate of healing as compared with the thirty-five-day freeze-dried graft seen in Figs. 2-A and 2-B. (High-power view, × 132.)

gators who were without knowledge of the method of preservation or postoperative time involved. There were no gross differences of opinion; a composite of the group opinion is presented in Table I.

Numerical values from 0 to 4 were assigned to each of the various factors or aspects of

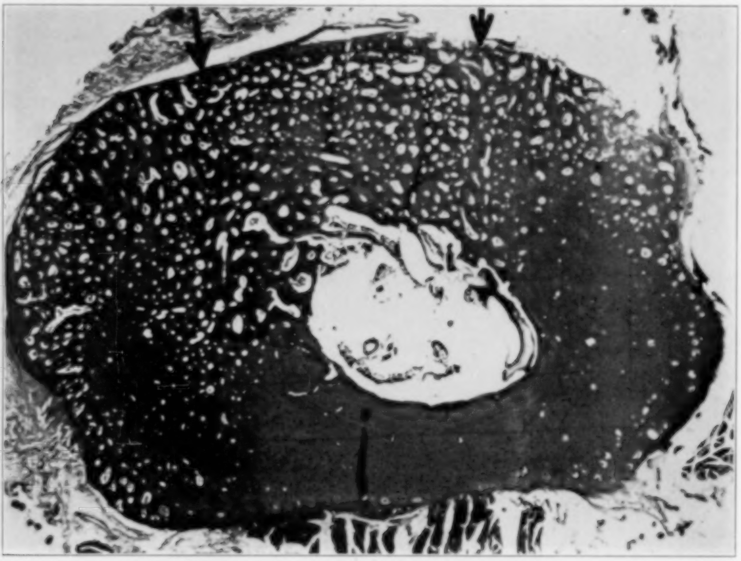

Fig. 4-A

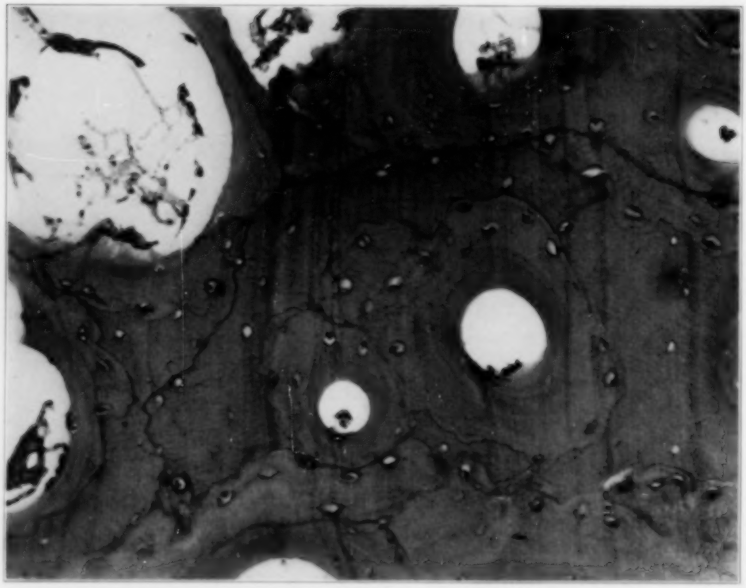

Fig. 4-B

In these photomicrographs of a ninety-day freeze-dried graft (OC36-L), there is advanced revascularization and perivascular new-bone formation with only a small amount of the graft left. The graft lies between the arrows in the low-power view. The over-all healing rate is slightly more advanced than that of the average of ten grafts in this group. (Fig. 4-A, × 8; Fig. 4-B, × 132).

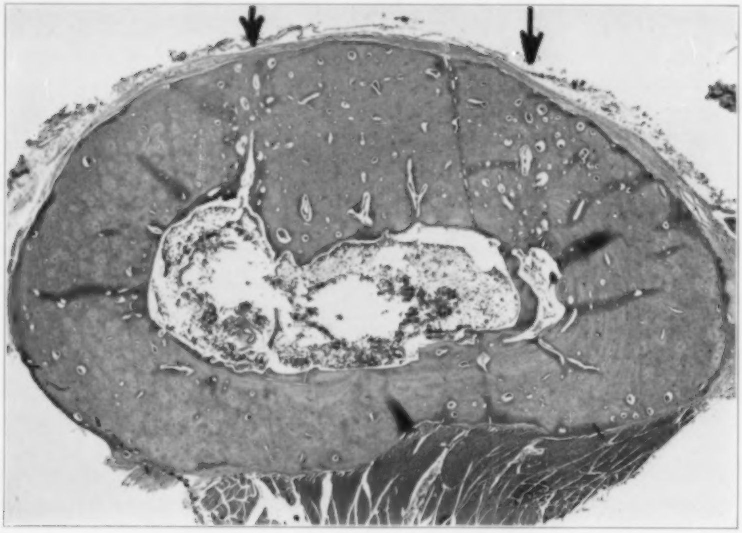

FIG. 5-A

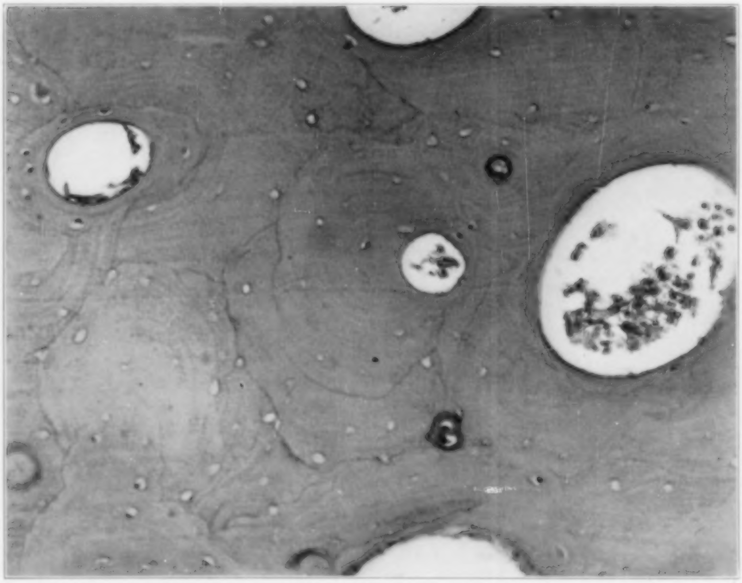

FIG. 5-B

These photomicrographs of a ninety-day frozen graft demonstrate marked retardation of healing as compared with the ninety-day freeze-dried grafts. The fact that this graft (seen between the arrows in the low-power view) is below the average rate of healing for this group of ten frozen grafts should be taken into account when comparing it with the freeze-dried graft in Figs. 4-A and 4-B. However, there was definite retardation generally in the frozen grafts at ninety days as compared with the healing of the freeze-dried grafts of this group. It is shown to emphasize the amount of retardation found in some of the frozen grafts. Although the graft has become well fixed to the host bone, most of the graft remains clearly visualized in the high-power view (× 132).

graft healing as indicated in Table I. The rough classification of stage of graft healing has been previously described and consists of four stages: (1) reactive new-bone formation; (2) revascularization; (3) perivascular new-bone formation; and (4) appositional bone growth. There is obviously some overlapping of these stages so that more than one stage may be prominent at the same time in a single graft.

In some of the sections, it was difficult to be sure how much of the graft remained purely on the basis of the presence or the absence of osteocytes in the lacunae. This is admittedly a somewhat unreliable criterion for the viability of a specific area of bone viewed microscopically. However, the total picture of the amount of revascularization, the color contrast, and the easily demonstrable perivascular new-bone formation, together with the presence or absence of osteocytes in the lacunae, usually made it possible to detect the areas of residual graft.

All obvious variables were eliminated in order to increase the accuracy of the results. Sections in which the grafts did not fit well were eliminated (OC7-L, OC9-L, OC10-L, OC13-L, OC15-L, OC35-L, and OC39-L). One animal was inadvertently brought to autopsy prematurely (OC40-L), and six grafts were discarded because of premature death from pneumonia (OC14-L, OC17-L, and OC31-L), encephalitis (OC44-L), dogfight (OC1-L), and anaesthesia (OC47-L). Two freeze-dried grafts (OC16-L and OC18-L) were discarded at random in order to present an equal number of frozen and freeze-dried comparisons at thirty-five and ninety days. Therefore, the grafts remaining for evaluation consisted of five frozen and five freeze-dried thirty-five-day grafts and ten ninety-day grafts of each type.

In compiling Table I, the factors most pertinent in graft-healing were used: the stage of healing, the amount of perivascular new-bone formation, and the amount of residual graft.

Storage time is obviously an important factor, and as stated previously this was longer for the freeze-dried (average 92.3 days) than for the frozen grafts (average 52.3 days). Therefore, the advantage of shorter storage time was favorable for the frozen grafts.

## RESULTS

Tables II-A and II-B summarize the results of the comparison of frozen and freeze-dried grafts which are presented in detail in Table I.

Freeze-dried grafts were definitely superior to the frozen grafts in all aspects. This superiority was more marked at thirty-five days than at ninety days. This is in agreement with but more striking than the impression gained from the original experiment comparing frozen and freeze-dried bone and may be attributed to the extent of the experiment and to the improvement in the techniques of processing and subsequent storage of the freeze-dried bone. The results indicated that frozen grafts performed only about 45 per cent. as well as freeze-dried grafts at thirty-five days and approximately 63 per cent. as well at ninety days.

## CONCLUSIONS

1. Freeze-dried cortical grafts in dogs are definitely superior to similar frozen grafts in the rate of healing. This is especially true in the earlier stages of healing, but it is also rather marked in the later stages.

2. This advancement of freeze-dried bone-graft healing occurred in spite of a considerably longer average storage period for freeze-dried grafts than for frozen grafts.

3. The superiority of freeze-dried bone grafts over frozen grafts demonstrated in this series is much more striking than that in the original experimental comparison. This is probably the result of improvements in the technique of freeze-drying and storage of freeze-dried grafts in vacuum.

NOTE: The authors greatly appreciate the invaluable service rendered by Dr. Lent C. Johnson of the Armed Forces Institute of Pathology in evaluating the results of this experiment and the help of his technical staff in the preparation of a majority of the microscopic bone slides. Commendation is also due the numerous corpsmen of the Experimental Surgery Division of the Naval Medical Research Institute and the Tissue Bank, Naval Medical School, who aided in carrying out this project.

## REFERENCES

1. Hyatt, G. W.; Turner, T. C.; Bassett, C. A. L.; Pate, J. W.; and Sawyer, P. N.: New Methods for Preserving Bone, Skin, and Blood Vessels. Postgrad. Med., **12:** 239–254, 1952.
2. Kreuz, F. P.; Hyatt, G. W.; Turner, T. C.; and Bassett, C. A. L.: The Preservation and Clinical Use of Freeze-Dried Bone. J. Bone and Joint Surg., **33-A:** 863–873, Oct. 1951.
3. Turner, T. C.; Bassett, C. A. L.; Pate, J. W.; Sawyer, P. N.; Gillmore, J. D.; Trump, J. G.; and Wright, K.: Sterilization of Preserved Bone Grafts by High-Voltage Cathode Irradiation. J. Bone and Joint Surg., in press.

## DISCUSSION

### Reconstructive Surgery of the Hand in Cerebral Palsy

*(Continued from page 1154)*

Two cases illustrate this premise. Both patients had a zero range of active extension in the fingers when the wrist was fixed in extension. In the first case, the fingers were in such severe flexion following arthrodesis that pressure areas developed in the finger tips as they pressed against the palm portion of the cast. Over a period of weeks, however, extension of the fingers improved. Over a period of months, extension became almost complete. [Photographs were shown revealing the range of flexion and extension in the fingers and the arthrodesis in ulnar deviation of the wrist. Photographs of the second patient were also shown revealing the maximum grasp before and after operation.]

In closing, I must say that the most important consideration is to treat only those hands that have potentially useful function; the percentage of spastic hands eligible for treatment will always be small, as Dr. Goldner has properly stated. In addition, there are a few cases in which the hands are corrected for cosmetic reasons alone; this applies particularly to female hemiplegic patients in whom the asymmetry in hand attitude may be so disfiguring.

My congratulations to Dr. Goldner for tackling this difficult subject so competently.

Dr. Goldner (closing): Dr. McCarroll's remarks emphasize the point made in the opening paragraph of the paper concerning the small percentage of cerebral-palsy patients who are eligible for surgery of the hand. Complete rehabilitation of the hand has not been accomplished in any of these cases but additional function has been obtained in all of those upon whom operations have been performed.

Dr. Cooper implied in his remarks that plaster immobilization or wrist fusion in ulnar deviation will hold the thumb out of the palm in all instances. This dictum has been tried but his results have not been obtained. The hypermobile metacarpophalangeal joint cannot always be controlled by ulnar deviation. Arthrodesis of this joint will give stability. If there is absence of an active thumb extensor or good tenodesis, tendon surgery is indicated. Plaster wedging has also been done in an effort to correct severe flexion in deformity of the fingers and wrist. In certain instances, this has been successful. In others, when there was no active extensor motor, it has not succeeded. Tendon transfers in conjunction with selective arthrodesis have given improvement in these cases. Even though the resulting function may not be through an active motor, there is adequate improvement when the deforming element is removed and a tenodesis established. The results following tendon transfers cannot be predicted in patients with cerebral palsy as they can in patients with poliomyelitis or peripheral-nerve injury.

# INJURIES OF THE EXTENSOR TENDONS IN THE DISTAL PART OF THE LEG AND IN THE ANKLE

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In the American literature little mention is made of injuries to the extensor tendons of the foot in the distal part of the leg and ankle. Burman[1, 2], Moberg, Lapidus, and Mensor and Ordway have emphasized the rarity of these injuries and the fact that they cause little functional impairment; nonetheless, these authors advised surgical repair. The injuries they referred to were isolated ruptures of single tendons; most traumatic lacerations, however, result in injuries of multiple tendons.

## ANATOMY

The main extensor muscles of the foot are the tibialis anterior, the extensor hallucis longus, the extensor digitorum longus, and the peronaeus tertius. Of these, the first three are the most important. At the distal portion of the leg the tendons of the tibialis anterior, the extensor hallucis longus, and the extensor digitorum longus with their distal muscle fibers pass under the transverse crural ligament and the cruciate crural ligament (Fig. 1). As the tendons pass under these ligaments, they lie on the distal part of the tibia. This arrangement converts the passage into a tight osseofibrous canal. Each of the tendons has a separate sheath which provides a gliding mechanism for the tendon as it "turns a corner"[4] in front of the ankle and distal part of the leg. In this region the anterior tibial tendon may have a to-and-fro excursion of 6.5 to 7.5 centimeters. These observations have been emphasized by Mayer.

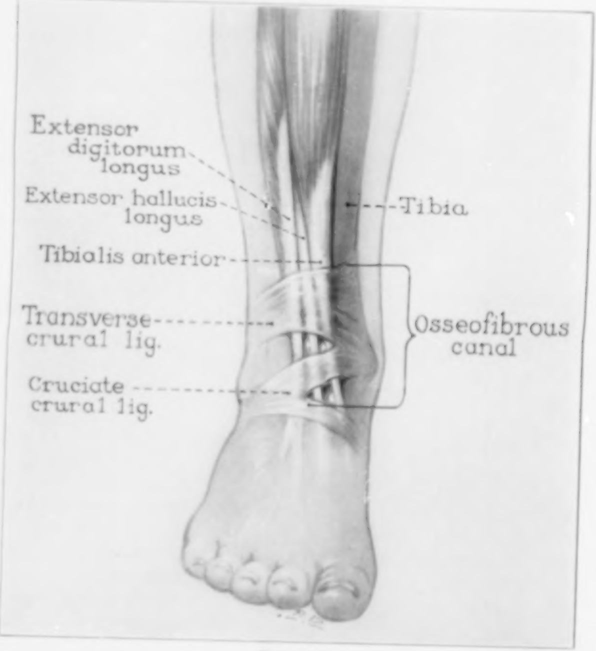

FIG. 1

Anatomical drawing of the three main extensor muscles of the foot, with their tendons. The transverse crural and cruciate crural ligaments help to form the tight osseofibrous canal in which injury of the extensor tendons is fraught with hazard.

It can be seen, therefore, that lacerations of the extensor tendons of the foot in the distal tibial region

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TABLE I

FRESH INJURIES TO THE EXTENSOR APPARATUS OF THE FOOT

| Case No. | Age and Sex | Tendons Injured | Associated Fractures | Suture Used Initially | Method and Length of Follow-up | Result |
|---|---|---|---|---|---|---|
| 1 | 59<br>M | Right peronaei and tibialis anterior | None | Silk | Examination 1 yr. after injury | Good |
| 2 | 36<br>M | Right tibialis anterior and extensor hallucis longus | Lower third of tibia | Catgut | Letter from patient, 10 yrs. | Good |
| 3 | 31<br>M | Left tibialis anterior and tibialis posterior | Neck of talus | Plastic (Bunnell pull-out) | Recent examination, 3 yrs. | Good |
| 4 | 38<br>M | Right tibialis anterior and extensor digitorum longus | None | Silk figure-8 | Letter from patient, 3½ yrs. | Good |
| 5 | 31<br>M | Left tibialis anterior, extensor hallucis longus, extensor digitorum longus, tibialis posterior; peronaei partly involved | Distal third of tibia | Not recorded | Recent examination, 11 yrs. | Good |
| 6 | 11<br>F | Right peronaeus longus, tibialis anterior, extensor digitorum longus, extensor hallucis longus | None | Chromic catgut | Recent examination, 8 yrs. * | Fair |
| 7 | 8<br>M | Left tibialis anterior, extensor digitorum longus, extensor hallucis longus | Distal part of tibia | Silk | Recent examination, 3 yrs. | Poor |
| 8 | 48<br>M | Right tibialis anterior, extensor digitorum longus, extensor hallucis longus | Ankle and subtalar joints | Not recorded ** | Recent examination, 3½ yrs. | Poor |

* Three months after the last operation.

** A split-thickness skin graft was also applied at the time of repair.

could, in the process of healing, cause these tendons to become bound down in the osseofibrous canal to the tibia, to each other, to the ligaments which comprise this canal, or to an overlying scar in the skin and subcutaneous tissues.

## ANALYSIS OF CASES

We reviewed the records of all injuries which involved the extensor tendons of the foot in the osseofibrous canal and which were treated at the Mayo Clinic during the period 1935 through 1952; we found that there were twelve patients with thirteen such injuries, one patient having bilateral injuries. Eight of the patients had fresh and four had old injuries; the patients in the latter group had received their primary treatment elsewhere. A summary of the data on these patients is given in Tables I and II.

In eight patients the injury was caused by machinery or tools used about the farm, such as silo blowers, mowing machines, and tractors; in two it resulted from automobile accidents; and in one each it was caused by a piece of glass and a tin can, respectively. The results of treatment were ascertained on the basis of recent examinations by one or the other of the authors in seven cases, by an examination one year after injury in one case, and by letters received in four cases (five injuries).

In an analysis of the results of treatment the patient was considered to have a *good* result if function of the foot and ankle was normal or nearly so, and a *fair* result if there

TABLE II

OLD INJURIES TO THE EXTENSOR APPARATUS OF THE FOOT

| Case No. | Age and Sex | Tendons Injured | Associated Fractures | Time from Injury to Definitive Repair (*Months*) | Suture Used for Definitive Repair | Method and Length of Follow-up | Result |
|---|---|---|---|---|---|---|---|
| 9 | 26<br>M | Right tibialis anterior | None | 36 | Silk | Recent examination, 6 yrs. | Good |
| 10 | 22<br>M | Right tibialis anterior and extensor hallucis longus; left tibialis anterior, extensor hallucis longus, extensor digitorum longus | Both tibiae and fibulae; delayed union, right tibia | 6 | Not recorded | Recent examination, 11 yrs. | Good on both sides |
| 11 | 16<br>F | Right tibialis anterior and extensor hallucis longus | None | 5 | Silk | Letter from patient, 15 yrs. | Good |
| 12 | 42<br>F | Right tibialis anterior and extensor hallucis longus | None | 8 | Wire | Letter from patient, 15 mos. | Fair |

was some function of the tendons and their muscles. In the two patients classified as having a fair result, the foot could not be actively dorsiflexed beyond a right angle, but the patient was satisfied from the standpoint of function, since there was not a "slapping" gait. The patients classified as having a *poor* result were unable to dorsiflex the foot and had a feeling of instability.

Cases 1 through 5 (Table I) represent the patients with fresh injuries who obtained a good result. The tendons in this group were sutured with varied materials, and various techniques were used. In one case the suture material used was not recorded. This case is of special interest. The patient had sustained severe injuries to the distal portion of the left leg, including fractures of the tibia and fibula. All structures of the left leg except for the posterior neurovascular bundle, the Achilles tendon, and a portion of the peronaei were divided. The patient was re-examined ten years after injury and was found to have an excellent result. Figures 2-A and 2-B show the range of active foot and ankle motion obtained by this patient.

Case 6 represents a fair result. In this case, multiple reconstructive procedures were performed in an attempt to restore active dorsiflexion of the foot and ankle. Figure 3 shows the status of the patient's leg and foot before the last attempt at surgical repair. This case, which will be reported in more detail, illustrates the difficulties and complications which may arise in an injury which at first seemed not too serious.

Cases 7 and 8 were classified as representative of a poor result. In each case, all three extensor tendons were divided. In Case 7 silk was used for the primary repair; in Case 8 the suture material used was not recorded. The poor result in Case 8 was undoubtedly due to injury of the ankle and subtalar joints. The patient was re-examined four years after the original injury and was found to have considerable limitation of extension (dorsiflexion). Stiffness in the ankle and subtalar joints accounted for much of his disability.

In the cases of old injuries (Table II) treated primarily elsewhere, the presenting complaints were weakness or lack of dorsiflexion, instability of the foot, and limp (slapping or dropped foot). One patient (Case 10), however, had bilateral fractures of the distal end of the tibia and had not borne weight; the injury to the tendons was noted on physical examination. Following late repair of the severed tendons and application of a sliding bone graft, this patient, when recently examined, was found to have a good result.

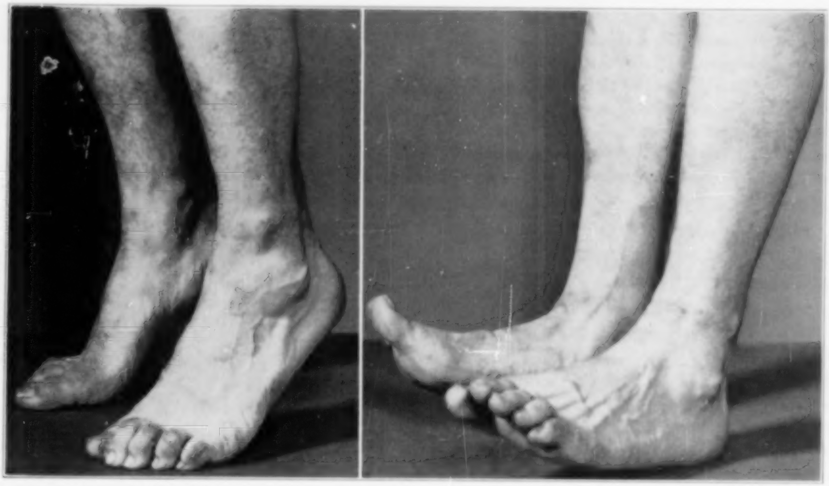

FIG. 2-A FIG. 2-B

Case 5. Photographs showing function of the feet and ankles ten years after an injury sustained when a sickle-bar mower produced compound fractures of both tibiae and fibulae about 2.5 centimeters above the ankles. In the left leg the tibialis anterior, extensor hallucis longus, extensor digitorum longus, peronaeus tertius, and tibialis posterior tendons were completely severed. The peroneal tendons were partially severed.

Fig. 2-A: Patient standing on toes.

Fig. 2-B: Patient standing on heels. Note the transverse scar on the lower part of the left leg. The outline of the tibialis anterior, extensor digitorum longus, and peronaeus tertius tendons distal to the scar can be seen.

Of patients with old injuries, three were judged to have a good result and one a fair result after surgical repair. The patient with bilateral injuries obtained a good result on each side. Therefore, there was a total of four good results and one fair result in this group. The tendons were repaired three to thirty-six months after the original injury in these cases.

The patient with an old injury who obtained a fair result had an infection of the wound following the original injury. Because of this, surgical treatment was deferred for six months. At operation the tendons were found to be bound down to the tibia and the surrounding soft tissues in a mass of scar tissue. The tibialis anterior and extensor hallucis longus tendons were freed and imbricated, and a piece of polythene sheeting was placed beneath them. Unfortunately, another infection of the wound developed after operation. Although the infection subsided after the polythene had been removed, the result remained poor for many months. In a recent communication, however, the patient stated, "I am walking perfectly straight with no limp. However, I cannot raise my foot and toes as high as the other but this does not hinder me in walking."

## ILLUSTRATIVE CASES

CASE 5. A male farm laborer, thirty-one years old, was admitted to the Hospital on July 23, 1943, after a farm accident in which both legs were caught in a mowing machine.

Examination revealed a nearly complete severance of the left leg through the lower third with severance of the anterior tibial artery and the deep peroneal nerve, the tibialis anterior, extensor hallucis longus, extensor digitorum longus, and tibialis posterior tendons, and a compound comminuted fracture of the tibia and fibula. It was evident that the triceps surae tendon, the posterior neurovascular bundle, and the peroneal vessels were intact; the peroneal tendons were partially divided.

The left tibia was internally fixed with two Vitallium screws. The tendons were repaired (the type of suture material was not recorded), as was the superficial peroneal nerve. The fascia was closed with interrupted sutures and the skin was closed with interrupted dermal sutures. There were no tendon or nerve injuries in the right leg and the right tibia was fixed with a four-hole Lane plate.

The casts were removed four months later and the patient resumed weight-bearing at that time. He was not seen again until 1954, eleven years after operation, at which time he had no complaints. Examination revealed excellent strength and function of the tibialis anterior and extensor digitorum longus tendons. He had a full range of motion in the left ankle. He had no limp or detectable loss of strength in motions of the foot and ankle. The result was classified as good.

The following case will be reported in detail since it demonstrates so well the difficulties that may be encountered if the initial operation fails.

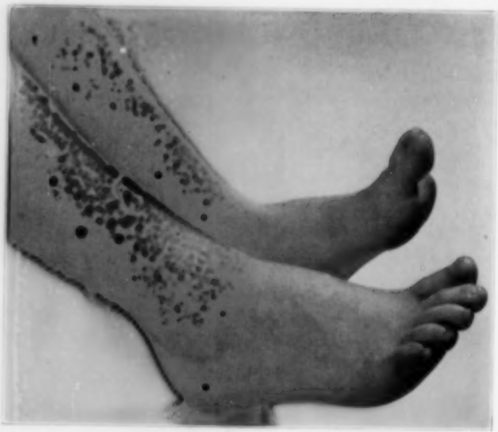

FIG. 3

Case 6. The patient is unable to extend (dorsiflex) the right foot eight years after laceration of the peronaeus longus, tibialis anterior, extensor hallucis longus, and extensor digitorum longus tendons. The Achilles tendon was secondarily contracted. Note the adherent scar over the anterior aspect of the lower part of the leg. The patient had undergone three operative procedures in an attempt to restore her ability to extend (dorsiflex) the foot and ankle.

CASE 6. On June 2, 1946, an eleven-year-old girl fell while playing and sustained a laceration of her right leg on a piece of dirty glass. Within a period of four hours, thorough cleansing and débridement of the diagonal laceration, which was seven centimeters long and located seven centimeters above the ankle, was carried out. The tibialis anterior, extensor hallucis longus, and extensor digitorum longus tendons were found to be completely severed. The peronaeus longus was partially severed. The wound was elongated and the tendons were repaired with interrupted catgut sutures. A short plaster-of-Paris cast was applied to the leg after routine closure of the skin. Prophylactic tetanus and gas-gangrene antitoxins were administered and the patient was given 15,000 units of aqueous penicillin intramuscularly every three hours for five days. Her temperature was never more than 100.5 and after the third day it was normal. She was allowed to leave the hospital on the sixth day after operation. The wound healed *per primam*, and immobilization was continued for one month after operation. Upon removal of the cast the patient was unable to dorsiflex her foot. In spite of physical therapy she was still unable to activate the anterior tibial muscle or its tendon three weeks later, and it was feared that the sutured tendon ends had separated.

Eight weeks after operation, the site of injury was explored surgically. It was found that the ends of the tendons had separated and that the six-centimeter gap between them was filled with scar tissue. The distal part of the tendon of the extensor digitorum longus was removed and was used as a free graft to bridge the gap in the tibialis anterior tendon. Silk was used as the suture material. The wound was closed and a long cast was applied to the leg. Penicillin was administered for three days. The temperature was normal after the second day and the patient was dismissed from the Hospital on the fourth day. When the cast was changed three weeks later, purulent drainage was found to be present. Immobilization was continued for two months. It was necessary to remove the silk sutures which had become exposed in the wound. Healing of the skin was not complete until three months later.

A drop-foot and gradually a cock-up deformity of the great toe developed, since the extensor hallucis longus tendon seemed to be functioning. A painful callus also developed over the plantar aspect of the fifth metatarsal head.

On June 13, 1949, three years after the original injury, the interphalangeal joint of the great toe was arthrodesed and the extensor hallucis longus tendon was transplanted through drill holes into the first metatarsal. Although improvement in function was obtained by this procedure, dorsiflexion of the foot was possible to only 20 degrees less than a right angle. She continued to experience pain along the lateral border of her foot; her gait in September 1950 still left much to be desired.

We lost track of the patient from September 1950 until March 1954, when she returned because of a contusion of the right knee and of the old scar on the left leg; the contusion had been sustained when she fell on some steps three days previously. The patient was still unable to walk on her heel or to dorsiflex the left foot to a right angle. The extensor tendons were felt to be bound in scar tissue at the site of the old injury, and the tendo achillis was contracted.

On April 14, 1954, seven years and ten months after the original operation, the scar was excised, the tendo achillis was lengthened, and the upper two thirds of the crural ligament were excised. The distal portion of the tibialis anterior tendon was woven into the hypertrophied extensor hallucis longus tendon. The proximal end of the extensor hallucis longus tendon was split and half of it was sutured to the musculotendinous juncture of the tibialis anterior muscle which still appeared capable of function. This time, Bunnell pull-out wire and buried stainless-steel fine twisted wire was used to suture the tendons. A sliding skin graft was applied to give a fine scar without tension over the anterior aspect of the leg. The resultant defect on the posteromedial aspect of the leg was covered with a split-thickness skin graft. A long plaster-of-Paris cast was applied to the lower extremity, with the ankle dorsiflexed and the knee flexed to 90 degrees. Primary healing of both wounds resulted, and one month after operation the portion of the cast above the knee was removed. Two weeks later the remainder of the cast was removed and an elastic bandage was applied. After removal of the cast, dermatitis appeared on the leg which was quite troublesome for several months. With daily physical therapy the function of dorsiflexion continued to improve, and when she was last seen the patient was considered to have a fair result.

Case 7. An eight-year-old boy was admitted to the Hospital on the evening of July 18, 1952, one hour and ten minutes after an injury in which the left leg was caught in a hay mower. There was a deep transverse laceration in the lower fourth of the right leg anteriorly. The patient was taken to surgery immediately.

At operation the laceration was found to have penetrated to the posterior cortex of the tibia. The extensor hallucis longus, tibialis anterior, and extensor digitorum longus tendons had been severed. In addition, the anterior tibial artery and vein and the greater saphenous vein and saphenous nerve had been divided. After the incision had been extended, the ends of the tendons were identified and were repaired with silk sutures. Soft tissue was drawn between the tibia and the tendons in an attempt to prevent adherence of the repaired tendons to the underlying bone. The skin was closed with interrupted sutures. The foot and ankle were immobilized in a toe-to-knee cast for six weeks.

When the cast was removed the patient was unable to dorsiflex the foot or toes. He received intensive physical therapy for one month but after that failed to return. He returned at our request in March 1954, twenty months after operation, at which time examination revealed a limp due to foot drop. The extensor hallucis longus pulled very weakly through the scar on the distal anterior pretibial region. The tibialis anterior and extensor digitorum longus tendons seemed bound down by scar tissue in the distal pretibial region and were not functioning.

On June 14, 1954, exploration of the wound showed that the three extensor tendons appeared to be longer because of the interposition of scar tissue. The tendons were bound together by scar tissue and it was impossible to delineate them. The scar was excised and the conjoined tendons were shortened, a barb pull-out tendon suture being used. The wound was closed in layers with interrupted sutures and the foot and ankle were immobilized in a Robert Jones dressing and a right-angle foot splint.

On July 7, 1954, three weeks later, the barb pull-out tendon suture was removed; at this time the patient had no dorsiflexion of the foot or toes. He then received intensive physical therapy, and after four and a half months he was able to dorsiflex the toes and foot weakly. In the seventh month, he was still unable to dorsiflex the foot to a right angle. It was then decided to perform a Jones tendon transplantation since the patient could dorsiflex the great toe strongly. Hence, one month later, the extensor hallucis longus tendon was transferred to the neck of the first metatarsal, and the interphalangeal joint of the great toe was arthrodesed. In April 1955 the patient was still in a cast. The result to date is classified in Table I as poor.

Case 8. A man forty-eight years old was admitted to the Hospital on September 9, 1950, after an accident in which his right foot and ankle had been sucked into a silo blower. This resulted in a severe avulsion type of injury involving the right ankle and dorsum of the foot.

After thorough cleansing and débridement of the wound, exploration revealed the anterior tibial artery and deep peroneal nerve to be severed. The tibialis anterior, extensor hallucis longus, and extensor digitorum longus tendons were also found to be lacerated. A fragment of bone had been avulsed from the superior portion of the talus and there was damage to the talonavicular joint. The tendons were repaired (the type of suture material used was not recorded). The deep peroneal nerve was not repaired since it was severed below its motor branches. In suturing of skin it was necessary to use a split-thickness graft to complete the skin cover. The foot and ankle were immobilized in a posterior plaster splint which held the foot at a right angle.

The wound was dressed on the eleventh day; at that time it was observed that about 80 per cent. of the skin graft had taken. A short walking cast was applied to the leg, and the wound healed by secondary intention. The cast was removed during the eighth week and the patient was allowed to start walking. In the fifth month, it was noted that dorsiflexion at the ankle was limited and that subtalar motion was lacking entirely.

The patient was seen again, at our request, three and a half years after operation, in March 1954. At that time the range of ankle motion in dorsiflexion was to 100 degrees and in plantar flexion to 120 degrees. The tibialis anterior tendon and muscle were functioning at about 75 per cent. of normal power, and the extensor hallucis longus was functioning at about 50 per cent. of normal power. There was only a flicker of motion from the extensors of the toes. The patient complained of some pain and walked with a marked limp. Much of the disability could be attributed to traumatic arthritis, with loss of motion in the ankle joint and in the subtalar joints. The result was classified as poor.

Case 11. A sixteen-year-old girl was first seen at the Mayo Clinic on July 17, 1939. She had been in an automobile accident on June 13, at which time she had suffered a laceration five centimeters above the right ankle joint.

Examination revealed a depressed crusted scar five centimeters above the anterior aspect of the ankle. The patient was unable to dorsiflex the distal phalanx of the great toe and had marked weakness of dorsiflexion of the foot. As a temporary measure, she was fitted with a brace for a four-month period. On November 7, exploration of the anterior aspect of the leg and ankle region was performed. The tibialis anterior and extensor hallucis longus tendons were found to be divided. The proximal end of the extensor hallucis longus tendon had retracted; the distal end was sewed to the common extensor tendon of the toes. The tibialis anterior tendon was accurately repaired with silk sutures. The wound was closed with interrupted sutures and a plaster boot was applied. The cast was removed at the end of six weeks.

Two years later the result was judged to be good, dorsiflexion of the foot and toes being limited only slightly. A follow-up letter in 1954, fifteen years after the original injury, revealed that the patient was pleased with the result and that she apparently had normal function.

Case 12. A woman, forty-two years old, came to the Hospital on July 8, 1952, with the chief complaint of inability to dorsiflex the right foot. Nine weeks previously she had fallen on a tin can and had suffered a short, deep laceration at the junction of the middle and distal thirds of the anterior part of the right leg. The laceration had originally been repaired elsewhere and the patient had been told that "a tendon was cut and repaired". The repair was done immediately after injury, according to the patient. Examination revealed an inflammatory reaction with evidence of recent drainage at the site of the wound. The tibialis anterior and extensor hallucis longus tendons did not appear to be functioning at all. It was decided to defer surgical repair until all inflammation had subsided. The patient was fitted with a light piano-wire drop-foot brace.

On January 2, 1953, eight months after injury, exploration of the wound revealed that the tibialis anterior tendon was bound down in scar tissue, as was the extensor hallucis longus tendon. The divided ends of the tibialis anterior tendon seemed to be separated, but the extensor hallucis longus tendon seemed to be under fair tension. The tibialis anterior tendon was sutured with several wire sutures. A strip of thin polythene sheet 2.5 centimeters wide and 6.3 centimeters long was placed beneath the tendons and on the medial aspect of the tibia. A padded toe-to-groin cast was applied.

Three weeks after operation a low-grade infection of the wound was apparent. This drained and continued to drain until the polythene was removed. Owing to a misunderstanding, the patient failed to return for removal of the cast until four months later. At that time no dorsiflexion of the foot was evident. She was given physical therapy and was instructed to continue exercising her foot after she was sent home.

When she was last heard from, in March 1954, fifteen months after operation, the patient could dorsiflex her foot to a right angle and was well satisfied with the result. However, this patient was judged to have only a fair result.

## COMMENT

Injuries of tendons to the foot which occur in the osseofibrous canal are subject to the complications that follow injuries of all tendons in anatomically similar locations. The same principles of treatment which have now become so well established in injuries of the wrist and hand should apply to tendons of the foot if maximal function is to be regained. Primary repair of tendons, then, requires thorough evaluation of the injury, especially as regards the status of the surrounding skin, associated fractures, and the presence of infection. A well equipped operating room, good lighting, adequate instruments, capable assistance, complete anaesthesia, and a bloodless field as obtained by a pneumatic tourniquet are essential for the definitive treatment. Treatment consists of thorough toilet and débridement of the wound, complete hemostasis, repair of the injured tendons, and provision for adequate coverage of the skin. If these conditions for definitive treatment are not present, repair of the tendons as a secondary procedure, after the potentially infected wound has healed, is advisable.

It would seem logical to excise cleanly the sheath and the surrounding ligamentous structures at the site of tendon repair in an attempt to prevent adherence of the tendon in scar tissue. Non-absorbable sutures of wire or silk should be used for accurate approximation of the severed ends of the tendons after they have been squared off cleanly with a sharp knife. All devitalized shreds of muscle should be trimmed away. Additional incisions or any extension of the original laceration to secure retracted ends of tendons should be either transverse or curved, so that the edges of the skin, when sutured, do not overlie the repaired tendon in a longitudinal direction. In cases of severe injury of the extensor tendons of the foot it may be advisable to repair or reconstruct only the tibialis anterior and the extensor hallucis longus tendons, and in some instances only the former. In some cases secondary repair, tendon graft, or tendon transfer may be advisable at a later date, after adequate coverage of the skin has been provided.

After-treatment consists of the application of a well padded plaster-of-Paris cast over a firm protective dressing. The foot should be immobilized at a right angle, except when splinting in full dorsiflexion is required, so that as little strain as possible is placed on the suture line of the severed tendons. The extremity should be elevated until the immediate post-traumatic reaction has subsided, and immobilization in a cast should be continued for four to six weeks; longer immobilization is necessary if there are associated fractures. At the end of the period of immobilization, function should be restored by directed active motion.

## SUMMARY AND CONCLUSIONS

Injuries of the extensor tendons of the foot in the lower part of the leg or at the level of the ankle are comparatively rare. They are often associated with extensive injuries of the skin, subcutaneous tissues, ligaments, and underlying bone.

Of the thirteen injuries in this series, the results were classified as good in nine (69 per cent.), fair in two (15 per cent.), and poor in two (15 per cent.). The factors limiting successful repair were (1) the anatomy of the site of injury, (2) the number of tendons severed, (3) the presence of infection, (4) concurrent injury to the ankle or subtalar joint, and (5) the presence of an adherent scar and contracture of the Achilles tendon in old injuries.

The same principles of treatment which apply to injuries of the wrist and hand apply to lacerations of tendons of the foot that occur in the lower part of the leg or at the level of the ankle. If repair of the fresh tendon injury is not successful or if there is impaired function as a result of an old injury, late repair by tendon suture, tendon graft, or tendon transfer is indicated.

## REFERENCES

1. BURMAN, M. S.: Subcutaneous Rupture of the Tendon of the Tibialis Anticus. Ann. Surg., **100:** 368–372, 1934.
2. BURMAN, MICHAEL: Subcutaneous Strain or Tear of the Dorsiflexor Tendons of the Foot. Bull. Hosp. Joint Dis., **4:** 44–50, 1943.
3. LAPIDUS, P. W.: Indirect Subcutaneous Rupture of the Anterior Tibial Tendon. Bull. Hosp. Joint Dis., **2:** 119–127, 1941.
4. MAYER, LEO: Tendon Transplantations on the Lower Extremity. *In* Instructional Course Lectures, The American Academy of Orthopaedic Surgeons, 1949. Vol. VI, pp. 189–200. Ann Arbor, J. W. Edwards, 1949.
5. MENSOR, M. C., and ORDWAY, G. L.: Traumatic Subcutaneous Rupture of the Tibialis Anterior Tendon. J. Bone and Joint Surg., **35-A:** 675–680, July 1953.
6. MOBERG, ERIK: Subcutaneous Rupture of the Tendon of the Tibialis Anterior Muscle. Acta Chir. Scandinavica, **95:** 455–460, 1947.

# THE TREATMENT OF BONE AND JOINT TUBERCULOSIS *

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The recent acquisition of new and apparently effective drugs for treating tuberculosis has made it necessary to restudy our treatment of cases involving bones and joints. The first of the new drugs, streptomycin, gave results which in some instances were far better than expected, although they still fell short of being complete cures. Later the isonicotinamids were discovered and gave promise of still better results. Experience with both of these drugs still is quite recent, but enough data have been accumulated to permit our forming some preliminary conclusions and to enable us to decide to what extent we may rely upon these new tools and how much they may modify our concept of the treatment of the disease.

Before we can do this, it is necessary to take stock of what has been accomplished without these new agents. Only those who have treated joint tuberculosis before the era of modern surgery (1911) can appreciate adequately the revolution which was wrought by this therapy. Our clinics have ceased to be filled with patients returning for the adjustment of braces, the application of plasters, and the treatment of abscesses and sinuses; the "humpback" is rarely seen. This truly great advance was largely the work of Russell A. Hibbs, who earned by this achievement, if by no other, a place among the great orthopaedic surgeons.

A base line of comparison for the treatment of tuberculous joints by arthrodesis alone is afforded by the results attained in patients with tuberculosis of the hip at the New York Orthopaedic Hospital as reported by Hallock and Toumey. Of 170 patients operated upon from 1923 to 1931, 163 lived beyond the first year. In 112 (69 per cent.) of these, fusion was obtained by one operation. A second operation and, in a few cases, a third raised the number of successful results to 142 (87 per cent.). From 1915 to 1936, 199 patients with tuberculosis of the knee were subjected to arthrodesis [7]. Fusion was attained in 196 cases (98 per cent.), although sinuses persisted in seven of these cases.

Of equal interest are the results attained in 584 patients with tuberculosis of the spine on whom fusion operations were performed between 1911 and 1930 [6]. In this group it was found that the age of the patient was a significant factor. Among 332 children from one to ten years of age, 72 per cent. showed excellent results; another 6 per cent. lived but were not improved; and 22 per cent. died. Among 252 patients above the age of ten, the results were excellent in 53 per cent.; failure occurred in 9 per cent., and death in 38 per cent. These patients included many with advanced general disease and severe deformities. These results represent a great improvement over those of the early conservative treatment.

In judging the efficacy of any new treatment for tuberculosis of the joints, we must have in mind the pitfalls which were responsible for the long delay in recognizing the inadequacy of the old conservative methods of treatment. The first of these pitfalls was the failure to make accurate diagnoses. From 1904 to 1911, 210 cases of hip joint tuberculosis were treated at the Country Branch of the New York Orthopaedic Hospital; subsequently it was discovered that a wrong diagnosis had been made in forty-six (22 per cent.) of these cases. During this same period seventy-five patients were treated for tuberculosis of the knee; among these it was found that eleven (15 per cent.) had been erroneously diagnosed. At the Massachusetts General Hospital, Ghormley found that of forty-one diagnoses of definite tuberculosis, only twenty-seven (66 per cent.) were proved correct;

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* Presented before the Boston Orthopaedic Club, Boston, Massachusetts, November 15, 1954.

and that of fifty-two diagnoses of probable tuberculosis, only twenty-seven (52 per cent.) were proved correct. He also found that of forty-two patients for whom the diagnosis of tuberculosis was not even considered, eighteen (43 per cent.) actually had tuberculosis.

Clinical diagnoses, unaided by laboratory tests, have been shown to be wrong in about 25 per cent. of cases, regardless of the experience and competence of the surgeon. Diagnoses based upon x-ray findings have been wrong in about the same proportion. The tuberculin test is of value when negative but, when positive, gives no specific information. Culture and inoculation of guinea pigs by aspirated joint fluid gives a negative result in a significantly large number of cases that actually are tuberculous. In doubtful cases arthrotomy is the only means of making an accurate diagnosis. By combining sections of tissue culture and guinea pig inoculations, few if any cases will escape detection. In his study of 175 tuberculous cases in which arthrotomies were performed, Swift found that in 82 per cent. the correct diagnosis was established by frozen section done at the time of arthrotomy[5]. He also found that in 74 per cent. the preoperative clinical diagnosis was correct.

These facts have been known for a long time, but they are of sufficient importance to warrant emphasis. Unless we maintain a rigid standard of diagnosis, we cannot correctly evaluate the effects of the new drugs on the treatment of joint tuberculosis.

The second pitfall to keep in mind is failure to remember that tuberculosis of the joints is a disease characterized by remissions. In joint tuberculosis there often are long periods of quiescence which are followed by reactivation and reappearance of symptoms. For this reason all patients who have had joint tuberculosis, and especially those who still have movable joints, must be observed closely for years in order to make sure that the disease is not merely dormant and that what we thought was a cure is not just a remission.

In 1946, having received favorable reports of the effect of streptomycin therapy in pulmonary tuberculosis, we began to use this drug experimentally in patients with bone and joint tuberculosis. The results were excellent in some patients, for the most part in those with very active disease as manifested by fever, high sedimentation rate, anorexia, loss of weight, and rapid increase in the joint symptoms. These patients responded with a fall in temperature and sedimentation rate and with improvement in appetite and general well-being. In spite of these good results, however, we believed that arthrodesis was still necessary in almost all cases and that the value of the drug lay in increasing the patients' resistance and in making successful surgery more feasible.

Hope was entertained, nevertheless, that we might in some cases succeed in arresting the disease permanently without destroying the joint. It seemed that the most favorable cases for this attempt would be those in which the synovial membrane was involved but in which there was no evidence of a bone lesion. Three such cases of tuberculosis of the knee were selected. They were treated with streptomycin and then operated upon, as much of the synovial membrane as possible being excised. In two of these patients, a girl of sixteen and a boy of eighteen, there was found extensive disease of the synovial membrane, which was very thick, oedematous, and adherent in each. In these cases the disease continued to be active after the operation in spite of treatment with streptomycin; and after several months an arthrodesis was performed, following which, symptoms of the disease disappeared. The third patient was a girl, ten years of age, who likewise had well developed synovial disease but who also had involvement of the superior pole of the patella. The upper fourth of the patella was removed in addition to as much of the synovial membrane as was practical. She has been free of any symptoms for five years and has a movable, well functioning knee.

In 1952, Selikoff, Robitzek, and Ornstein reported remarkable improvement in a series of cases of pulmonary tuberculosis treated at Sea View Hospital by hydrazine derivatives of isonicotinic acid. At the same time, Bosworth, Wright, and Fielding reported equally promising results in a series of cases of bone and joint tuberculosis treated at the same hospital with iproniazid, one of the isonicotinic acid derivatives [1]. They selected for this test a group of their most severe and unpromising patients, patients who had failed to improve after streptomycin and surgery. With almost no exceptions they found that when the drug had been used, temperature fell, pain lessened rapidly, appetite improved, weight was gained, and a sense of well-being developed. Furthermore, they found that the discharge from sinuses lessened and became free from tubercle bacilli and that five of fifteen sinuses closed. Subsequent experience with a larger number of cases confirmed the impressions gained from the first series [2]. All the favorable results continued.

These investigators also found that the drug concentrated in the spinal fluid. This is a favorable circumstance in tuberculous meningitis, but it also gives rise to toxic manifestations as a result of action on the central nervous system. These toxic manifestations include dizziness, tremor, hypertonic reflexes, clonus, and euphoria. Other toxic symptoms produced by this drug are related to the sympathetic nervous system and frequently include dryness of the mouth, diaphoresis, weakness of visual accommodation, urinary hesitancy, obstipation, and impotence in males. A psychosis developed in two of the patients treated with this drug at Sea View Hospital (although in one of them only after the drug had been withdrawn), and another patient went into a coma with cerebrospastic convulsions. In most of the cases at that hospital, however, early recognition of the toxic symptoms and prompt reduction of the drug prevented the development of serious complications. The toxic effects of streptomycin, most important of which are deafness and vertigo due to damage to the eighth nerve, are well known.

It has been well established that in many cases the tubercle bacilli become resistant to streptomycin, and it has been reported from several sources that a similar resistance has developed to the isonicotinamids. In order to prevent or delay the development of resistance and in order to minimize the danger of toxic effects, it has been advised that streptomycin be given in smaller amounts concomitantly with the isonicotinamids. At the same time it has been suggested that para-aminosalicylic acid also be used.

Bosworth is of the opinion that iproniazid, while more toxic, is also more effective than isoniazid. The latter now is available for general use, but iproniazid thus far has been reserved for experimental study. At the New York Orthopaedic Hospital, we are treating parallel series of cases with iproniazid and isoniazid. The treatment is started with four milligrams of isoniazid or three milligrams of iproniazid per kilogram of body weight per day. If no toxic symptoms develop, the dose is increased to six milligrams of isoniazid or four milligrams of iproniazid per kilogram. At the same time one gram of streptomycin is alternated with one gram of dihydrostreptomycin for an adult three times a week, and from ten to fifteen grams of para-aminosalicylic acid are given daily. To some extent this process vitiates the experimental study of the isonicotinamids, but we feel that it is in the best interests of the patient.

In the majority of our patients, a spine fusion or arthrodesis has been performed when their condition has been deemed satisfactory, usually after a relatively short period of treatment. To date forty-eight patients have been treated in this manner. The results have been satisfactory and, we believe, are superior to those obtained when surgery is employed with streptomycin alone. We have been unable to detect any striking superiority in the effect of iproniazid over isoniazid, nor have we found the toxic effects of the former to be notably greater. Psychosis developed in three patients who had undergone prolonged treatment, and several other, minor toxic symptoms occurred, symptoms which ceased after reduction in the amount of drugs used. There was no case of deafness or vertigo.

An example of the successful treatment by drugs and surgery of a difficult case is that of L. S., a colored male, thirty-five years old (Figs. 1-A and 1-B). He had had interscapular pain for four years. This pain had become severe four days before admission and had been followed by increasing weakness in the left lower extremity. Two days before admission he had become unable to walk. When he was admitted to the Neurological Service, there was complete flaccid paralysis of the left lower extremity and from 50 to 70 per cent. loss of strength in the right lower limb. A diagnosis of intradural neoplasm at the level of the sixth thoracic vertebra was made, and a laminectomy was performed as an emergency. An abscess was encountered, and an orthopaedic consultation was sought. Roentgenograms showed a lesion of the sixth and seventh thoracic vertebrae and a paravertebral abscess. Costotransversectomy was performed, but relatively little pus was found. Streptomycin, isoniazid, and para-aminosalicylic acid were started; streptomycin was instilled in the wound daily. In the meantime complete paraplegia had developed. Three months later a paravertebral fusion was done from the fourth to the tenth thoracic vertebra. After that there was progressive improvement in the patient's general condition and continual recovery from the paralysis. Ambulation was started three months after the fusion operation, and at the end of the fourth month the patient was walking without support. The wound had closed. This condition has been maintained during the eighteen months since the operation.

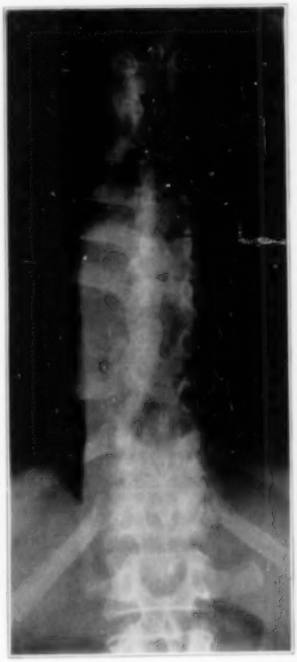

Fig. 1-A

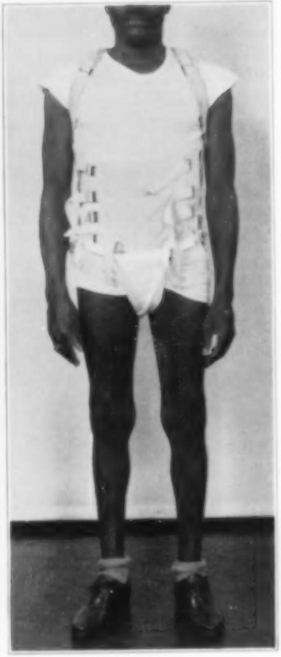

Fig. 1-B

Fig. 1-A: Tuberculous lesion in the thoracic spine. The patient has complete paraplegia. Costotransversectomy and surgical fusion of the lateral spine have been performed.

Fig. 1-B: After operation and drug therapy. The patient has recovered completely from paraplegia, and the spinal lesion has been arrested.

Most striking have been the effects of both streptomycin and the isonicotinic-acid derivatives upon abscesses and sinuses. It still is necessary to deal with the focus from which the abscess arises, but with the administration of these drugs there is a greater tendency for the abscess to become smaller and for the sinuses to close. Formerly we dreaded the necessity for incising a tuberculous abscess and avoided it if at all possible. Now, if the abscess fails to respond satisfactorily to aspiration and instillation of streptomycin and isoniazid, we do not hesitate to incise and drain, although we still prefer not to. After incision, a small catheter is inserted, and the drugs are instilled daily. With this treatment, the drainage usually diminishes rapidly and finally ceases.

The resolution of a large abscess with the help of drugs is illustrated by the case of A. D., a colored male, forty-three years old, who sought treatment because of a large swelling in the region of his left hip. This swelling had been present for four months and prevented him from going through subway turnstiles. He had had night sweats for several years and urinary frequency and nocturia for five years. Pain in both flanks had been noted at various times since 1937. At admission, on March 20, 1953, there was fullness in the left flank and a large mass in the upper third of his left thigh; the circumference of the left thigh was six and one-half inches greater than that of the right. The swelling of his thigh extended upward to his buttock. Roentgenograms showed a destructive lesion of the bodies and posterior arches of the third and fourth lumbar vertebrae. Urological examinations showed evidence of disease of the right kidney and ureter. Aspiration of the thigh abscess yielded 800 cubic centimeters of thick pus, the culture of which was positive for tubercle bacilli. A second aspiration on March 31 resulted in 500 cubic centimeters of pus. A spine fusion from the second to the fifth lumbar vertebra, in which iliac grafts were used, was done on April 8, 1953. After this, in six aspirations from April 11 to May 28, a total of 1,600 cubic centimeters of pus was removed. At each aspiration, one gram of streptomycin was instilled in the cavity; and iproniazid, streptomycin, and para-aminosalicylic acid were given systemically. The patient's general condition improved greatly, and the gains have been maintained to date.

Another complicated case, involving a large abscess, which was successfully treated was that of M. P., a colored woman, twenty-seven years old. She began to have low-back pain in December 1950. When seen in May 1951, there was tenderness over the lumbosacral joint and over the right buttock. Rectal examination disclosed a mass anterior to the sacrum. Roentgenograms showed a destructive lesion of the upper part of the sacrum. Although the Mantoux test was positive and the sedimentation rate was high, a neoplasm was suspected and a biopsy was done. Pus was found, and it was discovered that there was a large abscess anterior to the sacrum. The tissue removed was positive for tuberculosis. Streptomycin and para-aminosalicylic acid were administered, and on August 28, 1951, a hemifusion from the fourth lumbar vertebra to the first sacral vertebra was done, in which an iliac graft was used. She walked on November 30, 1951. She left the Hospital against advice, but reappeared in July 1952, febrile and with a high sedimentation rate. The abscess had recurred; she refused further surgical treatment. When seen again, in March 1953, there was a tremendous abscess of her left thigh, which had developed gradually. She was admitted to the Hospital, and 3,000 cubic centimeters of thick pus were aspirated from the left thigh. This abscess was an extrusion from the iliac fossa beneath the inguinal ligament. At a second aspiration on April 2, 1,300 cubic centimeters of pus were obtained, and three weeks later, 500 cubic centimeters. A sacro-iliac fusion was done on May 8, 1953. When last seen, she was in excellent condition and was pregnant. There was no abscess, and roentgenograms showed fusion of the lumbosacral and right sacro-iliac joints.

Although the treatment of tuberculous joints by a combination of streptomycin, isonicotinamids, and arthrodesis has been gratifying and satisfactory, it still falls short of the ideal goal of curing the disease without destroying the functioning of the joint. To what extent has the addition of these new aids made this goal possible?

On December 10, 1950, L. G., a colored girl, five years of age, complained of pain in the right hip; there was a limp (Figs. 2-A, 2-B, and 2-C). The symptoms, roentgenograms, and laboratory findings were all in keeping with the diagnosis of tuberculosis of the hip. She was admitted to the Hospital; and, after two weeks of treatment with streptomycin and para-aminosalicylic acid, the joint was explored. A cavity was found in the neck of the femur, adjacent to, but not involving, the articular cartilage. Granulation tissue was curetted from the cavity, and the cavity was packed with bone chips. Streptomycin was used locally and was continued systemically for sixty-nine days. A plaster spica was kept on for four and one-half months. At this time, the roentgenographic findings were favorable; and, within a restricted range, motion was painless. The patient began to walk with crutches. In November 1951, there was a full range of motion, and the

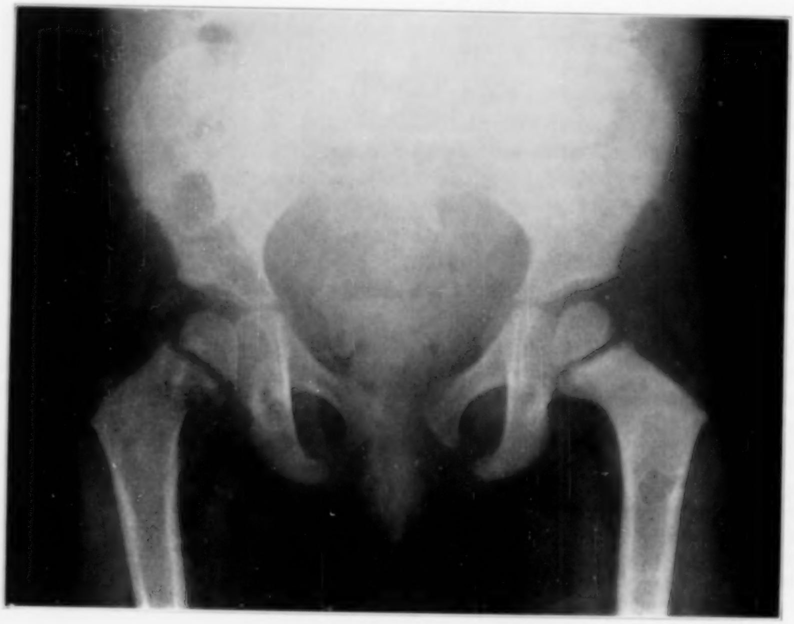

FIG. 2-A

Tuberculous lesion in neck of right femur.

lesion in the neck of the femur seemed to be healing. In July 1954, three and one-half years after the operation, she walked without limp and had a full range of motion. A coxa vara deformity was present, and measurements of the femora by scanogram showed a shortening of 1.9 centimeters on the right side. The lesion in the neck seemed completely healed.

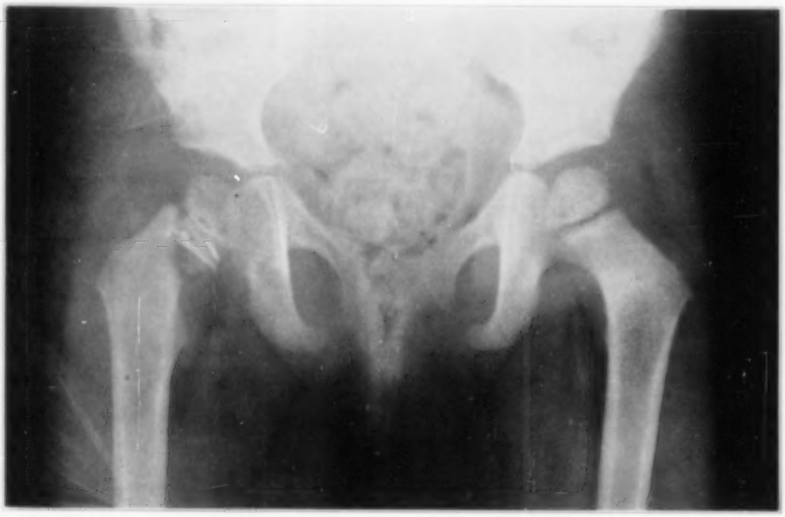

Fig. 2-B

Lesion after being curetted and packed with bone chips.

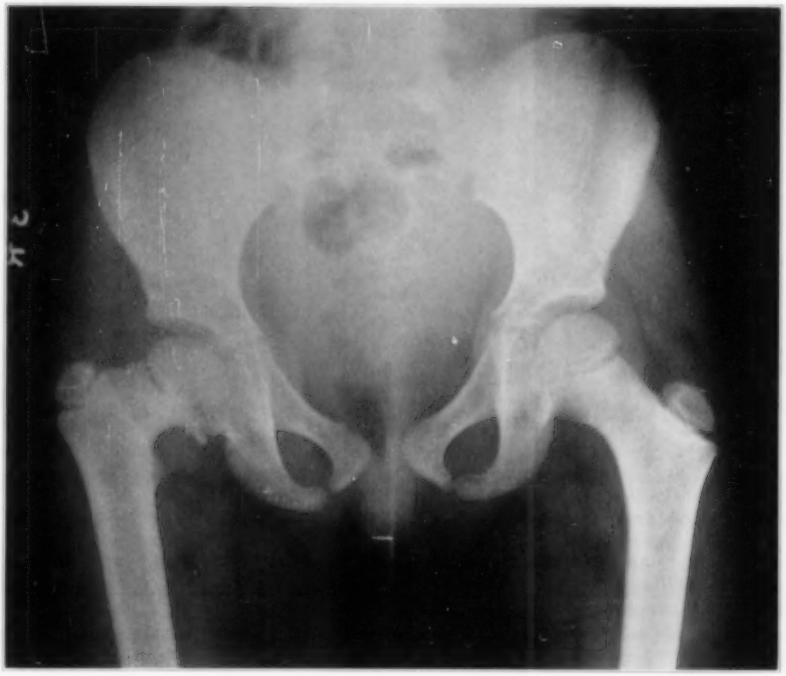

Fig. 2-C

Lesion after subsequent healing, with partial closure of epiphyseal plate.

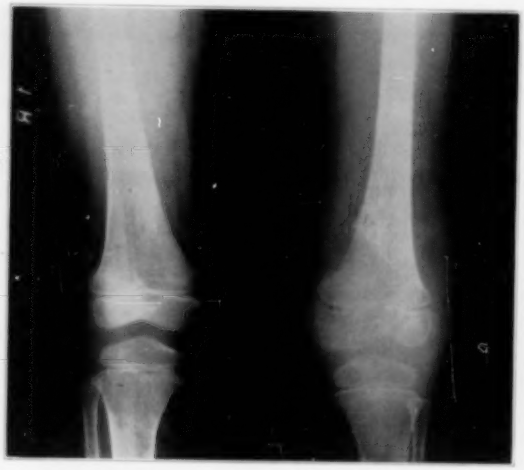

FIG. 3-A

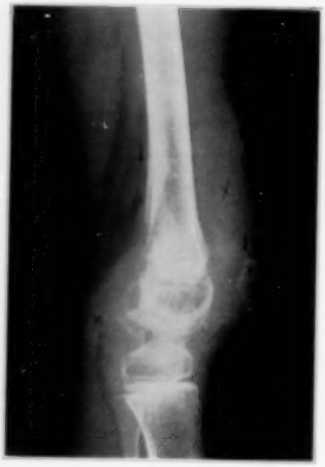

FIG. 3-B

Fig. 3-A: Destructive tuberculous lesion in metaphysis of left femur.

Fig. 3-B: Lateral view of same femur.

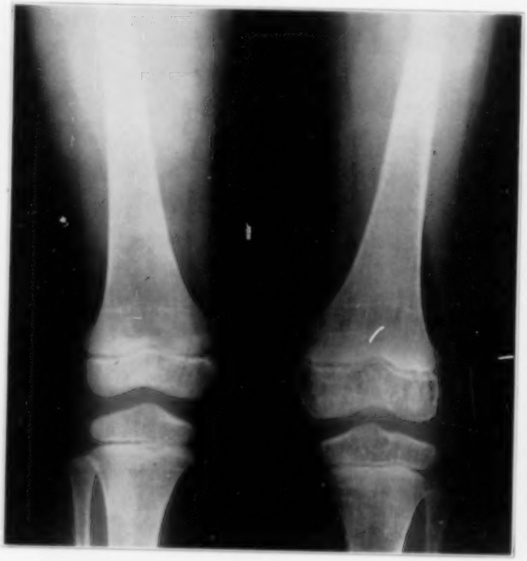

FIG. 3-C

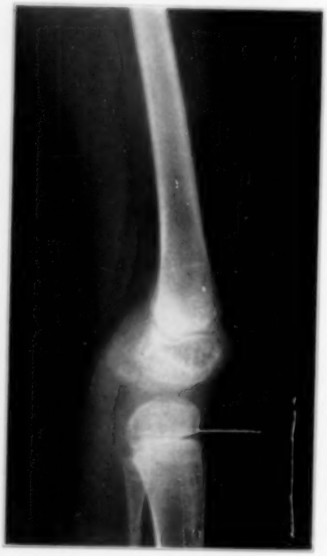

FIG. 3-D

Fig. 3-C: Femur following drug therapy only. The swelling has subsided, and the translucent area in the lower end has recalcified.

Fig. 3-D: Lateral view of left femur after drug therapy only.

A colored girl, L. M., two years of age, was admitted to the Hospital on June 13, 1952. There were symptoms of acute arthritis of three days' duration in the left hip. Her temperature was 104 degrees. Immediate incision and drainage revealed a purulent exudate, from which *Staphylococcus albus* was cultured. Roentgenograms gave evidence of osteomyelitis of the neck of the femur. An appropriate antibiotic was given, and she was kept in bed. On July 27, six weeks later, there was evidence in the roentgenograms of a sequestrum in the femoral neck; this sequestrum was removed at a second operation. The articular cartilage of the head still appeared to be undamaged. A section of the granulation tissue removed at this operation showed unquestionable tubercles. It is believed that from the start this was one of the unusual, acute fulminating cases of tuberculosis and that the *Staphylococcus albus* cultured at the first operation was a contaminant. Streptomycin and, later, isoniazid were given; the wound healed and the femoral neck began to repair. On October 20, 1954, there were no evidences of inflammation in the hip. The range of motion was complete, and the extremities were equal in length.

B. H., a white girl, four and one-half years of age, was seen January 13, 1954, because of a painless swelling in her left knee (Figs. 3-A, 3-B, and 3-C). This swelling had been present for eight months. Her temperature had risen from 103 to 105 degrees several days before admission, and on admission the erythrocyte-sedimentation rate was ninety-five millimeters. Tuberculosis was suspected, and an exploratory arthrotomy was done on January 22, 1954. Cultures made at this time were positive for tuberculosis, and sections showed typical tubercles. She was treated by immobilization in a plaster cast and received thirty milligrams of isoniazid twice daily and para-aminosalicylic acid once a day. Later 0.6 grams of streptomycin and dihydrostreptomycin were given alternately every other day. By March 31, the sedimentation rate had fallen to ten millimeters. Roentgenograms, which at the time of operation had shown no bone lesion, on February 13 revealed a cortical defect in the femur. This defect increased in size, and, on March 3, there appeared to be a large defect in the metaphysis and epiphysis.

Immobilization and antituberculous therapy were continued. On July 22 the knee was inspected, and it was found that the swelling had become much less. Roentgenograms showed that the large translucent area in the lower end of the femur had been recalcified. Motion was begun in the knee, but weight-bearing was prohibited. At readmission on September 27, there was minimal swelling, and the appearance of the femur in the roentgenograms was better. She was sent home. On November 1 there was slight swelling. Motion in the knee was from 180 degrees to 140 degrees. She was allowed to use crutches, although weight-bearing was still prohibited; the splint was removed daily to enable her to move the knee.

This patient will require much longer treatment and observation before the ultimate outcome can be determined, but the course thus far has been very favorable.

It has been known for years, of course, that a tuberculous lesion in a bone, apart from a joint, could be extirpated and cured without the joint being destroyed. The author operated on such a lesion in the lower end of the femur above the knee twenty-five years ago under the erroneous impression that it was due to pyogenic osteomyelitis. The patient has been followed since, and he has recovered completely without involvement of the knee. Prior to the three cases related previously, the author had not seen any cases in which lesions which were actually intra-articular were cured without the functioning of the joint being destroyed. Experience with these cases seems to warrant attempts to treat the bone lesion without arthrodesing the joint in patients in whom the articular surfaces are not destroyed. If these surfaces are destroyed, it is doubtful that a cure with a functioning joint can be obtained.

The experience with synovectomy and antituberculous therapy discouraged similar attempts, but it was planned to try a combination of the antituberculous drugs and rest, without surgery, when a suitable case of synovial knee-joint tuberculosis next presented itself.

On April 22, 1954, R. R., a girl, sixteen years old, came to the Clinic because of swelling and stiffness of the left knee. She had had an arthrodesis of the right hip for tuberculosis in 1948, and she also had had severe idiopathic scoliosis. The trouble in her knee had begun in January 1954. Motion in the joint was limited, and clear yellow fluid was aspirated. The injection of this fluid into a guinea pig resulted in a diagnosis of tuberculosis. The roentgenograms showed no bone lesion. She was admitted to the Hospital, where her knee was placed in a plaster cast, and she was treated with 200 milligrams of isoniazid and nine grams of para-aminosalicylic acid daily and with one gram of streptomycin three times a week. After several weeks a posterior plaster splint was substituted for the cast; and she was permitted to move the joint several times daily because otherwise motion was greatly restricted. On June 14, she was discharged from the Hospital with full range of motion and with only slight swelling. On September 15, she had full motion and no swelling. Roentgenograms still showed no bone lesion. She was walking with crutches.

The opportunity to observe the effect of the drugs alone on tuberculosis of the spine has been very limited because it has been felt that the patient's best interest dictated that a fusion operation should be done as soon as the general condition was favorable. In the spine, very little disability or impairment results from the fusion of a limited area, whereas very serious consequences result from failure to arrest the disease. One patient was followed, however, in whom intensive chemotherapy only had been used for a year.

The patient in this case was a boy, ten years old, who came to the Babies' Hospital on January 12, 1951, with tuberculous meningitis. He was intensively treated with streptomycin both intramuscularly and intrathecally in addition to promizole and para-aminosalicylic acid. A roentgenogram of his chest revealed spinal lesions of the seventh and eighth thoracic vertebrae. The meningitis finally was cured in July 1951, but only after he had suffered complete loss of vestibular function and partial loss of hearing. The spine lesion was treated first with a plaster jacket and later with a brace. The patient was discharged from the Hospital on November 3, 1951, and was readmitted on January 25, 1952, one year after the beginning of his meningitis. The destruction of the vertebrae had not increased and the shadow of the paravertebral abscess had disappeared, but it was thought that it would be safer for him to have a spine fusion, and so fusion was done. There was no evidence of reactivation of the lesion when he was seen in July 1954.

## CONCLUSIONS AND COMMENTS

Although experience with streptomycin and the hydrazides of isonicotinic acid is still too short to enable us to give any final opinion concerning their efficacy in the treatment of tuberculous bone and joint lesions, we believe that it is now safe to say that undoubtedly they exert a beneficial effect, an effect which is even striking in some active severe cases. The effect of these drugs also is striking in abscesses and sinuses. In the main, however, we believe that by themselves these drugs are not an adequate treatment and that they should be used as an adjunct to surgery. In our opinion, arthrodesis continues to be the safest and most effective method of treatment.

Examples have been cited of types of cases in which these drugs have resulted in apparent arrest of the disease with limited surgery and without arthrodesis. There is evidence that synovial tuberculosis of the knee may be treated successfully without surgery and that this treatment may also apply to tuberculosis of the tendon sheaths of the wrist and hand. Cautious experiments in this method of treatment should be continued.

It is important that in all cases thus treated the diagnosis should be proved beyond doubt either by aspiration and guinea pig inoculation or by biopsy. It also is essential to follow the patient for many years to make certain that there is not a reactivation of the disease.

## REFERENCES

1. Bosworth, D. M.; Wright, H. A.; and Fielding, J. W.: Marsalid in the Treatment of Tuberculous Orthopaedic Lesions. A Preliminary Report. Quart. Bull. Sea View Hosp., **13:** 52–57, 1952.
2. Bosworth, D. M.; Wright, H. A.; and Fielding, J. W.: The Treatment of Bone and Joint Tuberculosis; Effect of 1-Isonicotinyl-2-Isopropylhydrazine. A Preliminary Report. J. Bone and Joint Surg., **34-A:** 761–771, Oct. 1952.
3. Ghormley, R. K.: Joint Disease. A Clinical-Pathological Study. J. Bone and Joint Surg., **8:** 858–883, Oct. 1926.
4. Hallock, Halford, and Toumey, J. W.: Hip-Joint Tuberculosis Treated by Fusion Operation. An End-Result Study of One Hundred and Seventy Cases. J. Am. Med. Assn., **103:** 1836–1840, 1934.
5. Robitzek, E. H.; Selikoff, I. J.; and Ornstein, G. G.: Chemotherapy of Human Tuberculosis with Hydrazine Derivatives of Isonicotinic Acid. Preliminary Report of Representative Cases. Quart. Bull. Sea View Hosp., **13:** 27–51, 1952.
6. Swift, W. E.: Frozen-Section Diagnosis of Tuberculous Joints. J. Bone and Joint Surg., **18:** 641–647, July 1936.
7. Swift, W. E.: End Results of the Spine-Fusion Operation for Tuberculosis of the Spine. J. Bone and Joint Surg., **22:** 815–823, July 1940.
8. Toumey, J. W.: Knee Joint Tuberculosis. Two Hundred and Twenty-Two Patients Treated by Operative Fusion. Surg., Gynec., and Obstet., **68:** 1029–1037, 1939.

# A REPORT OF FOUR PROVED CASES OF TUBERCULOUS BONE OR SYNOVIAL INFECTION TREATED WITH STREPTOMYCIN

BY JAMES DOUGHERTY, M.D., AND MARY S. SHERMAN, M.D., CHICAGO, ILLINOIS

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The observations of Waksman and his associates on the effectiveness of streptomycin against tubercle bacilli and the subsequent use of this drug in skeletal tuberculosis led to many independent attempts to define the value of streptomycin as a specific in this disease. The early papers on the subject were optimistic; but, as failures occurred because of injudicious case selection, drug toxicity, inadequate surgery, or insufficient dosage, the reports steadily became less sanguine. With time, streptomycin came to be administered selectively and adequately; and now, as the early results of this improved regimen become available, the future of the drug in the treatment of skeletal tuberculosis once more seems promising.

In a recent symposium [10], a number of authorities expressed the conviction that streptomycin is a valuable adjunct to surgery in the treatment of osteo-articular tuberculosis. In a recent article, DeRoy and Fisher reported that encouraging short-term results had been obtained in fifty-two patients by chemotherapy combined with surgical drainage and open packing of wounds. These authors feel, however, as do others[3,8], that "in closed bone lesions, the use of streptomycin alone has failed to control the progress of the disease in most cases". Harris, Coulthard, and Dewar concluded that streptomycin "is of the greatest value in promoting primary healing of a closed wound after excision of a tuberculous sinus and its focus of origin".

In the treatment of tuberculous synovitis, streptomycin may prove to be of special value [7]. Recent reports[1,2,7] have cited cases in which apparent arrests of synovial disease were obtained by combined surgical and antibiotic therapy and in some instances by streptomycin alone. Smith and Bailey recently reported that in five cases of synovial tuberculosis of the knee in which roentgenograms showed no bone foci, streptomycin combined with plaster immobilization was very effective. In those cases there was no recurrence of the disease for from three to six years, as shown by clinical tests. Our experience in four cases supports this current belief that tuberculous synovitis can sometimes be checked without extensive synovectomy or fusion of the joint. In three of our patients (Cases 1, 2, and 3) pockets of diseased bone were curetted and the synovial membrane was left intact (except for the removal of biopsy material). The patients were then treated with streptomycin and para-aminosalicylic acid for six to twelve months with apparent arrest of the local disease, as shown by clinical tests and roentgenograms. They have all remained well for over three years and now exhibit a full range of painless motion in the previously involved joints. In the fourth patient, active synovial infection was evident, but no bony involvement was demonstrated either by x-ray examination or at operation. Biopsy only was performed. He received streptomycin and para-aminosalicylic acid for eight months, and, after only three months of bed rest, he was permitted activity. It has now been two years since the discontinuation of treatment, and the patient appears well.

It is evident from the descriptions just given and from the more detailed presentations which will follow that streptomycin has been of great benefit in the treatment of these patients. There has been in each case an apparent arrest of the pathological process, and motion has been retained in the four joints involved. It is especially noteworthy that no open packing or immobilization was necessary, and that the activity of the patient was limited for only a few months in three of the four cases.

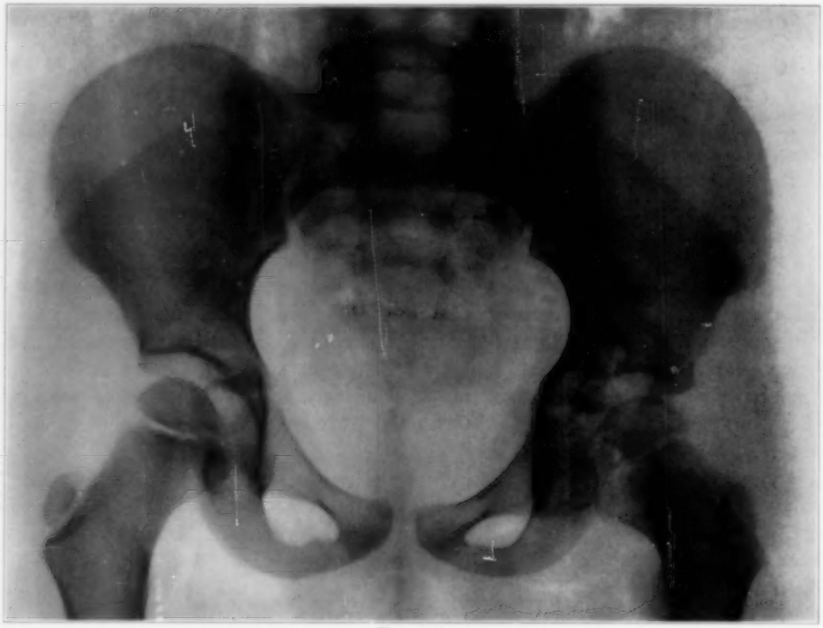

FIG. 1-A

Case 1. Roentgenogram of the pelvis, January 3, 1951. This film shows an area of destruction in the ilium above the left acetabulum. It also discloses a developing lesion in the epiphysis and neck of the femur.

We agree with Bosworth[2] that "the answer to the question of complete healing of synovial lesions . . . following prolonged periods of streptomycin will have to await the future". Nevertheless, present evidence seems to justify the initial treatment of many cases of synovial tuberculosis by streptomycin combined with surgery, as much of any bone focus which is not readily accessible to antibiotic drugs being removed. Arthrodesis can be performed later if it seems necessary.

CASE 1. C. P., a girl, four years of age, entered The University of Chicago Clinics with a slight limp and with a pain in the left hip of seven months' duration. A physical examination revealed definite limitation of motion in the left hip with some atrophy of the thigh and calf. Roentgenograms revealed a destructive lesion of the ilium just above the acetabulum and a developing lesion of the capital femoral epiphysis and neck (Fig. 1-A). The tuberculin test was positive at 1:10,000. Arthrotomy of the left hip revealed thick yellow pus in a cavity just above the acetabulum. No pus was found in the joint proper, although the synovial membrane was lined with reddish-gray granulations. Curettage of the bony defect was performed, and biopsy of the synovial membrane was done. Microscopic examination of the synovial membrane revealed tuberculous granulation tissue (Fig. 1-C). Pus from the bone lesion produced tubercle bacilli when cultured and injected into a guinea pig. The patient was given 0.5 gram of dihydrostreptomycin intramuscularly and six grams of para-aminosalicylic acid orally every day. She was kept in bed for eight months and was then allowed to use crutches and was discharged. Full weight-bearing was begun one year after treatment had been instituted, and at that time there was a complete range of painless motion. Roentgenograms made four months after resumption of weight-bearing showed evidence of the filling in of the destructive bone foci and the preservation of normal cartilage space (Fig. 1-B). The patient has remained well for four years.

CASE 2. S. K., a boy, four years of age, entered the University Clinics with a complaint of pain in the right shoulder of six months' duration. An examination revealed that the extremes of abduction and extension were painful, and that there was tenderness over the head of the humerus. The skin tuberculin test was strongly positive at 1:10,000, and roentgenograms of the shoulder (Fig. 2-A) revealed a destructive lesion in the proximal humeral epiphysis. The joint was explored, and pus and gray hemorrhagic soft tissue was curetted from an opening made in the greater tuberosity. Synovial changes were noted, and microscopic examination of the synovial membrane (Fig. 2-C) revealed active tuberculous granulation tissue. For three

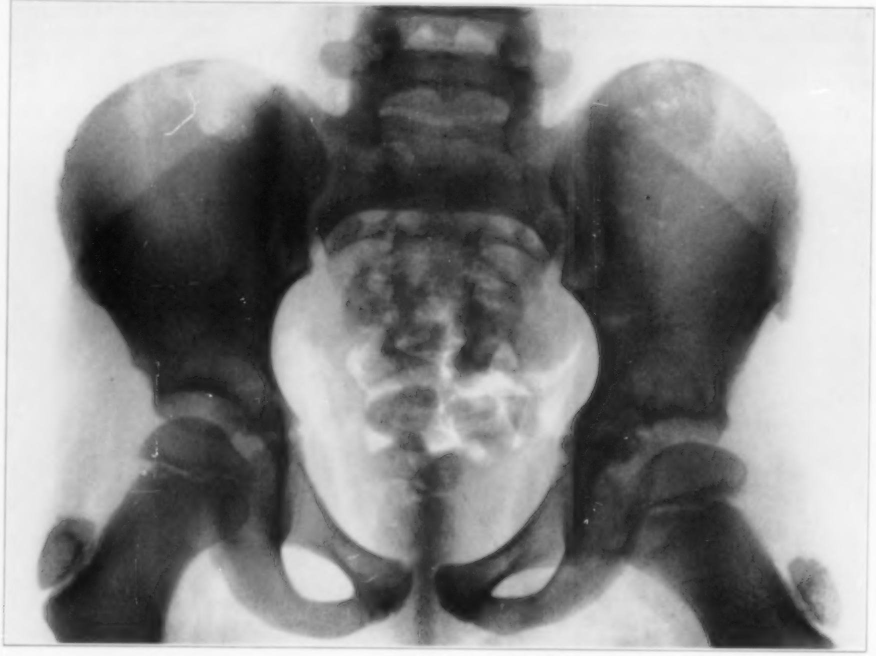

FIG. 1-B

Case 1. Roentgenogram of the pelvis, November 1, 1952. Considerable healing of all lesions is evident There is, however, some extrusion of the femoral head apparently due to the disease.

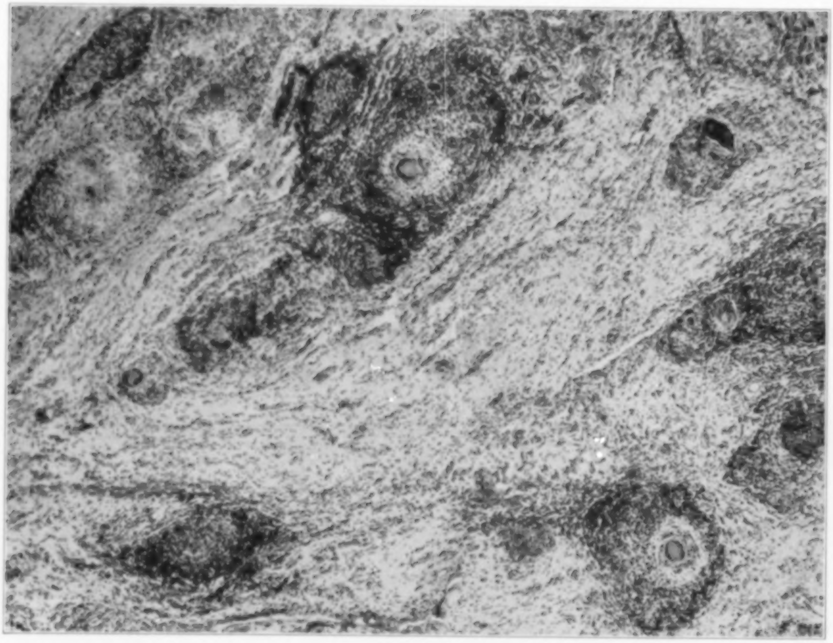

FIG. 1-C

Case 1. A photomicrograph (× 30) showing active disease of the synovial membrane with numerous Langhans giant cells.

and one-half months the patient was treated daily with one gram of dihydrostreptomycin given intramuscularly and six grams of para-aminosalicylic acid given orally. Four years after the discontinuation of the treatment, his shoulder is painless and motion is normal. A roentgenogram made recently (Fig. 2-B) showed complete filling of the old area of destruction.

CASE 3. K. W., a girl, three years old, entered the Hospital with a painless swelling in the right knee of three months' duration. The physical examination showed no abnormality except for the diffuse swelling

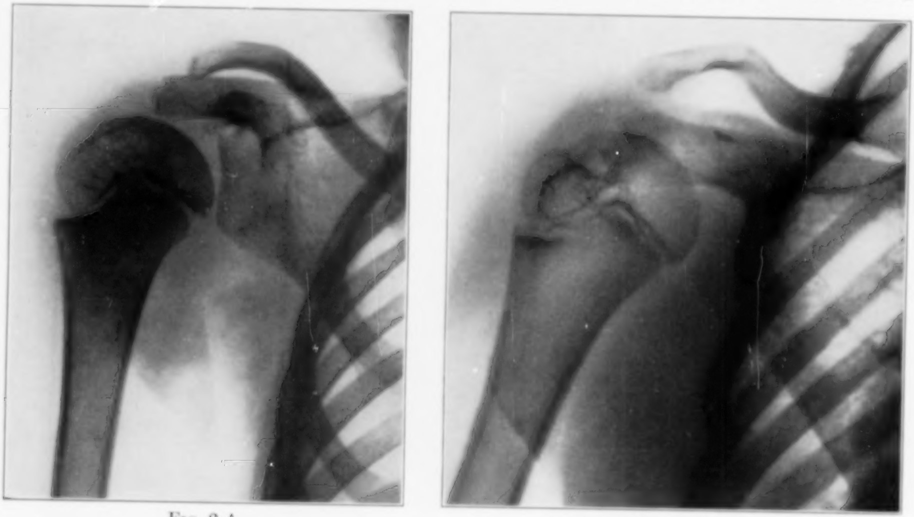

FIG. 2-A FIG. 2-B

Fig. 2-A: Case 2. Roentgenogram of the right shoulder, June 23, 1950. This preoperative roentgenogram shows an area of decreased density in the humeral epiphysis.

Fig. 2-B: Roentgenogram of right shoulder, January 29, 1955. Complete repair of defect is evident.

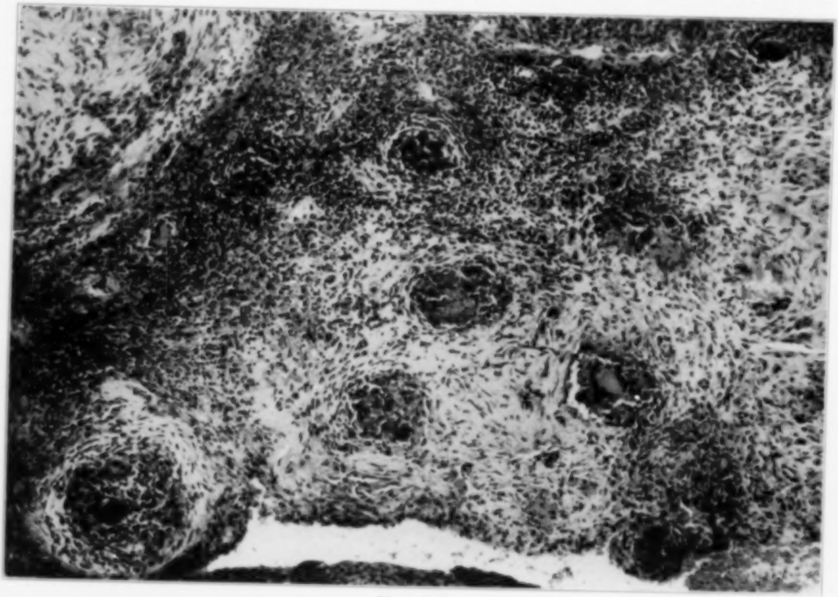

FIG. 2-C

Case 2. This photomicrograph (× 70) shows several tubercles with typical giant cells.

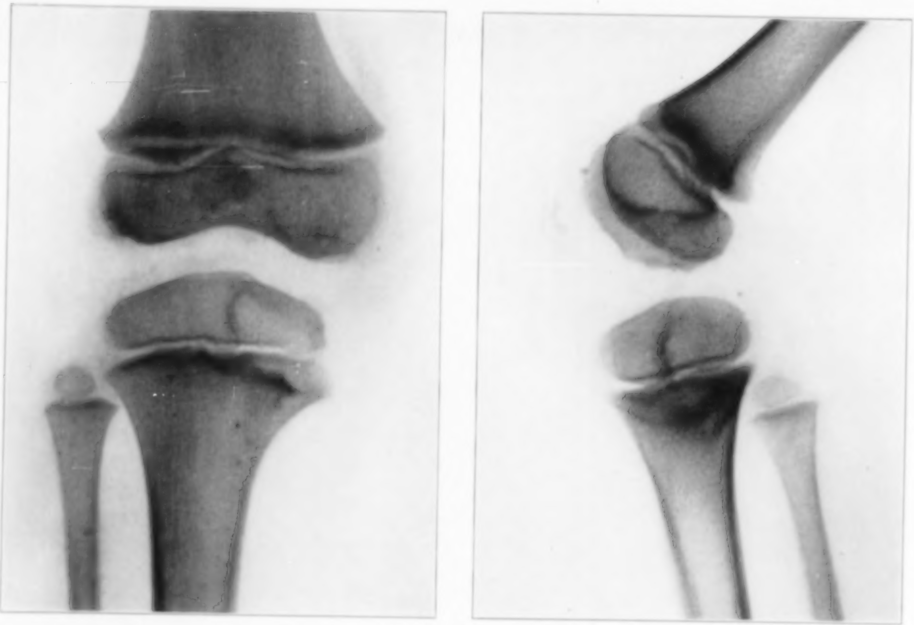

FIG. 3-A

Case 3. Roentgenograms of the knee, June 8, 1950. Initial areas of radiolucency on the medial aspect of the tibial epiphysis and metaphysis are evident.

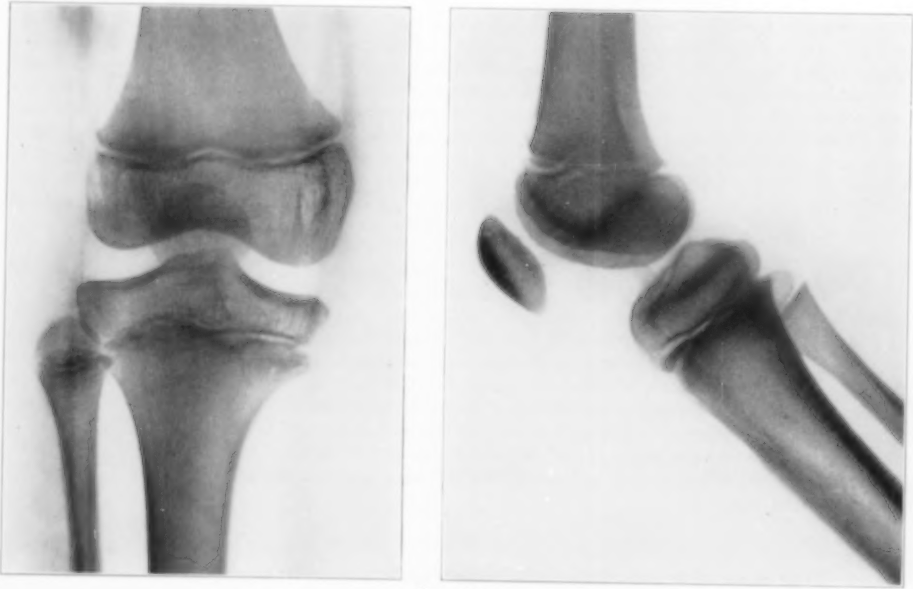

FIG. 3-B

Case 3. Roentgenograms of the knee, January 22, 1955. The radiolucent area has filled in.

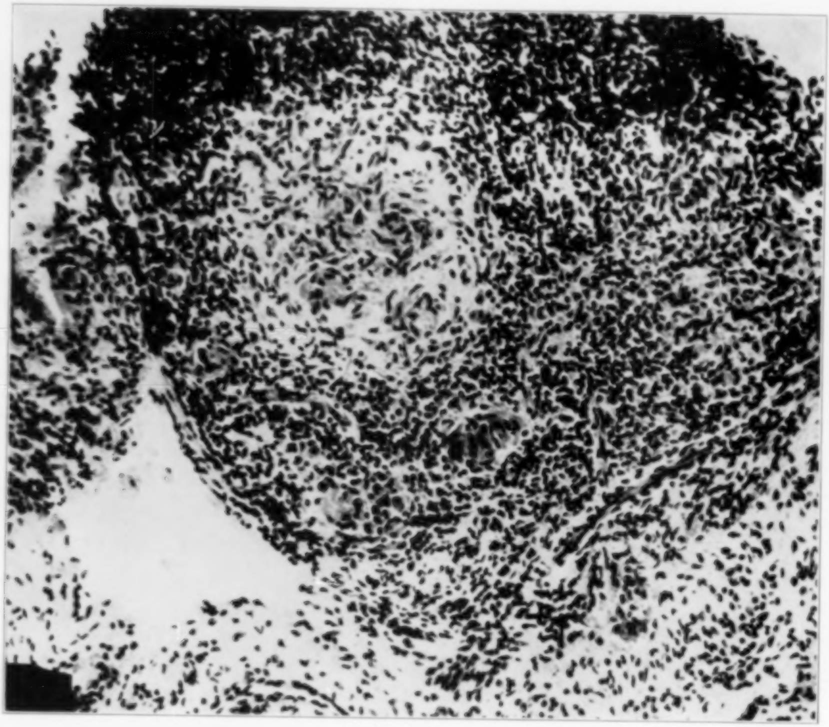

FIG. 3-C

Case 3. A photomicrograph (× 170) showing active synovial disease with typical central tubercle.

about the right knee. A tuberculin skin test was positive at 1:10,000, and a roentgenogram of the knee showed that there was an area of radiolucency on the medial aspect of the proximal tibial metaphysis and epiphysis (Fig. 3-A). A biopsy and a curettage were performed. Microscopic sections of the tissue removed at operation showed active tuberculosis (Fig. 3-C), and fluid from the knee joint, inoculated into two guinea pigs, produced tuberculosis in both. Daily doses of streptomycin (0.5 gram) and para-aminosalicylic acid (six grams) were started, and a plaster-of-Paris dressing was applied. The cast was replaced by a brace after six months, and chemotherapy was discontinued. At that time, she was permitted to walk for brief periods without the brace and to be without it at night. Full activity without support was permitted after nine months. Three and one-half years after discontinuation of all treatment, the knee is painless and has normal motion. Recent roentgenograms (Fig. 3-B) show repair of the old defects.

CASE 4. In T. A., a Negro boy, four and one-half years of age, there had been intermittent swelling and stiffness of the right knee for one year. The physical examination, which otherwise gave normal results, showed slight swelling and temperature elevation in this knee, plus a moderate restriction of motion. The skin tuberculin test was strongly positive at 1:10,000. A roentgenogram of the knee showed no bony changes (Fig. 4-A), and cultures of aspirated joint fluid produced no growth. The articular cartilages also appeared normal, but arthrotomy showed that the joint capsule was thickened and the synovial membrane was oedematous and inflamed. Microscopic examination of the synovial membrane revealed chronic active tuberculous synovitis (Fig. 4-C). Dihydrostreptomycin (0.5 gram) and isonicotinic acid hydrazide (150 milligrams) were administered daily for eight months, and the patient was kept at bed rest for three months. At present, two years after discontinuation of the therapy, this boy has a normal knee, as shown by clinical tests and roentgenograms (Fig. 4-B).

## SUMMARY

1. Four cases of tuberculous arthritis in children were treated.

2. In the one case in which involvement seemed limited to the synovial structures, streptomycin therapy alone appears to have arrested the disease.

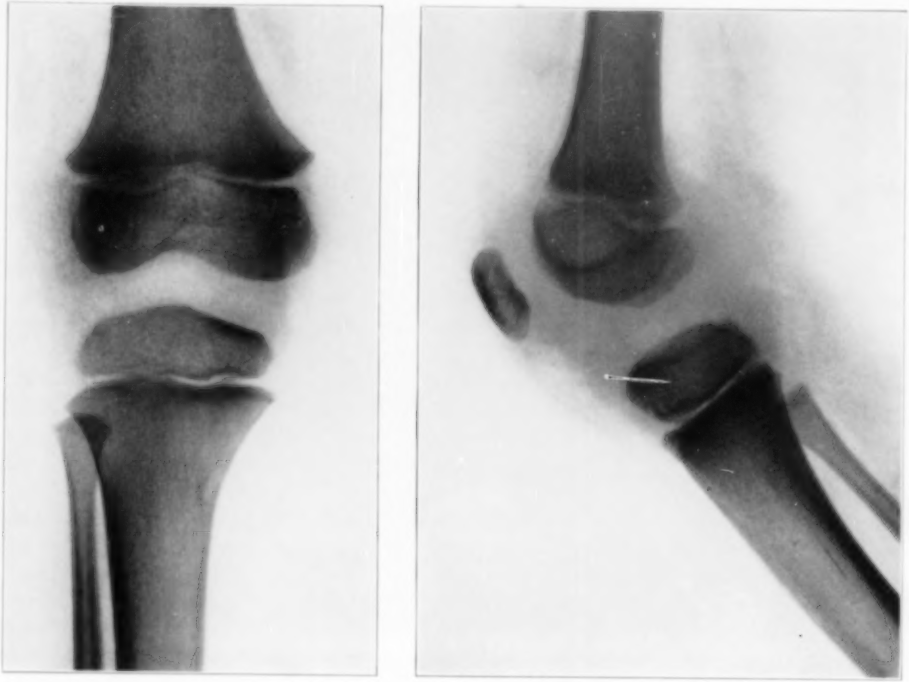

FIG. 4-A

Case 4. Roentgenograms of the right knee, May 15, 1952. No evidence of bone destruction is present.

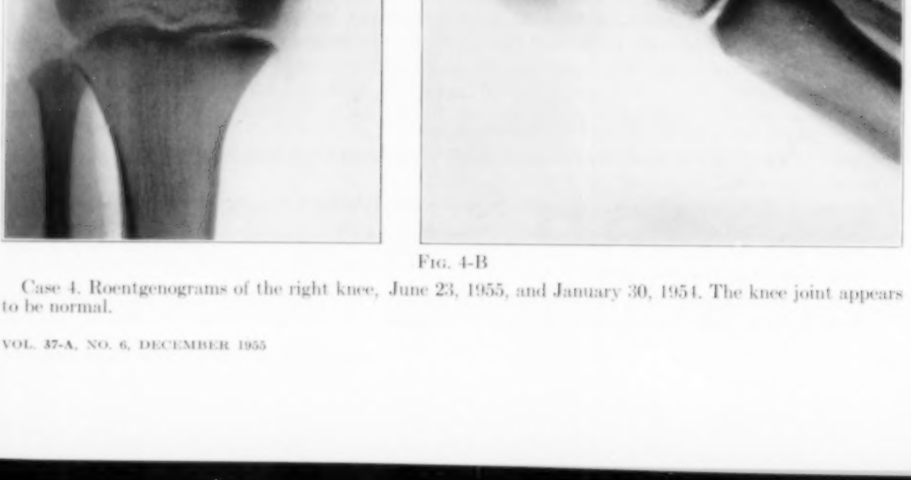

FIG. 4-B

Case 4. Roentgenograms of the right knee, June 23, 1955, and January 30, 1954. The knee joint appears to be normal.

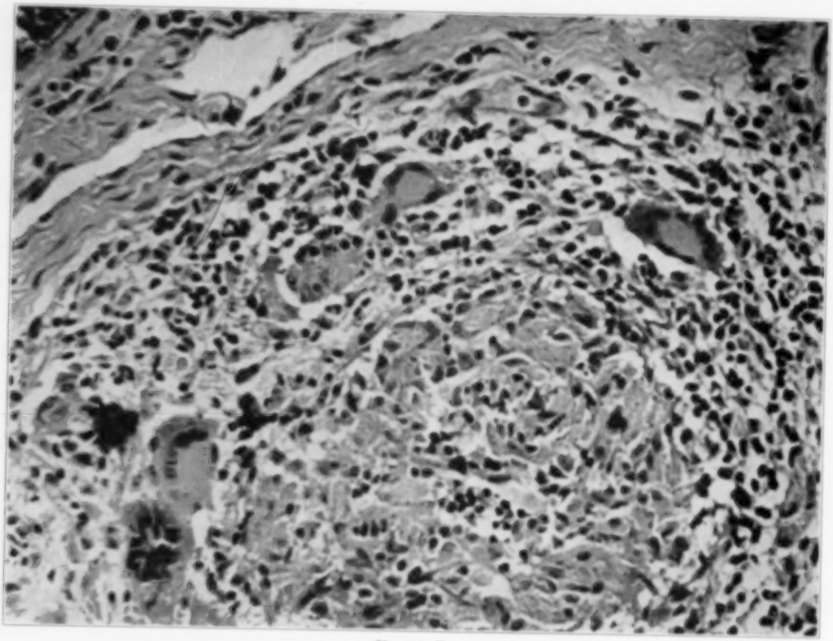

FIG. 4-C

Case 4. This photomicrograph (× 390) shows typical tubercle with Langhans giant cells.

3. In the three cases in which there was a concomitant focus of tuberculous osteomyelitis, surgical curettage of the bone focus together with streptomycin therapy seems to have been effective.

4. All wounds healed *per primam.* Synovectomy, open packing, and intra-articular injections of streptomycin were not employed.

5. In three of the four cases, no immobilization was employed.

6. We feel that good results may be obtained from the early treatment of tuberculous arthritis by streptomycin.

## REFERENCES

1. BICKEL, W. H.; YOUNG, H. H.; PFUETZE, K. H.; and NORLEY, THEODORE: Streptomycin in Tuberculosis of Bone and Joint. J. Am. Med. Assn., **137:** 683–687, 1948.
2. BOSWORTH, D. M.: Symposium: Streptomycin in the Treatment of Bone and Joint Tuberculosis. (*Closing Discussion.*) J. Bone and Joint Surg., **34-A:** 330, Apr. 1952.
3. BOSWORTH, D. M.; DELLA PIETRA, A.; and FARRELL, R. F.: Streptomycin in Tuberculous Bone and Joint Lesions with Mixed Infection and Sinuses. J. Bone and Joint Surg., **32-A:** 103–108, Jan. 1950.
4. DEROY, M. S., and FISHER, HARRY: The Treatment of Tuberculous Bone Disease by Surgical Drainage Combined with Streptomycin. J. Bone and Joint Surg., **34-A:** 299–330, Apr. 1952.
5. HARRIS, R. I.; COULTHARD, H. S.; and DEWAR, F. P.: Streptomycin in the Treatment of Bone and Joint Tuberculosis. J. Bone and Joint Surg., **34-A:** 279–287, Apr. 1952.
6. SCHATZ, ALBERT; BUGIE, ELIZABETH; and WAKSMAN, S. A.: Streptomycin, a Substance Exhibiting Antibiotic Activity Against Gram-Negative and Gram-Positive Bacteria. Proc. Soc. Exp. Biol. and Med., **55:** 66–69, 1944.
7. SMITH, A. DEF.: Symposium: Streptomycin in the Treatment of Bone and Joint Tuberculosis. (*Discussion.*) J. Bone and Joint Surg., **34-A:** 330, Apr. 1952.
8. SMITH, A. DEF., and I-SEN YU, HORACE: Streptomycin Combined with Surgery in the Treatment of Bone and Joint Tuberculosis. J. Am. Med. Assn., **142:** 1–7, 1950.
9. SMITH, W. S., and BAILEY, R. W.: Effect of Streptomycin in Synovial Tuberculosis of the Knee. J. Am. Med. Assn., **152:** 792–794, 1953.
10. SYMPOSIUM: Streptomycin in the Treatment of Bone and Joint Tuberculosis. J. Bone and Joint Surg., **34-A:** 254–298, 1952.

# CONSERVATIVE APPROACH IN THE TREATMENT OF FRACTURES OF THE CALCANEUS *

BY LEONARD BARNARD, M.D., AND JOHN K. ODEGARD, M.D., OAKLAND, CALIFORNIA

We have been unhappy with our results in the treatment of fractures of the calcaneus which involved the subtalar joints.

We have tried the recommended procedures, attacking the fracture in turn with knife, chisel, and pins. These measures have all been concerned with the surgically impossible accomplishment of restoration of an impacted, weight-bearing cancellous bone to its normal form and function.

The variety of approaches to this problem of anatomical restoration, which have filled our textbooks and journals for the past thirty years, bear eloquent witness to the frustration inherent in its solution [3, 7-9, 11, 12, 14]. Cotton, in the early part of the century, was one of the first to attempt restoration of width; he was concerned primarily with the piling up of excess callus beneath the lateral malleolus. Using a mallet and pad in the early cases [5] and a chisel in the older ones [6], he succeeded only in stimulating a variety of surgical attacks. In 1929, Böhler crystallized and formalized all restoration attempts with his skeletal traction, compression clamp, and long immobilization in plaster. Conn, a few years later, had apparently become discouraged and advocated early triple fusion after reduction by manipulation, lateral compression, and skeletal traction with a clamp and pins. Indeed, he made the astute observation in 1935 that there was a clear correlation between anatomical deformity, function, subjective symptoms, and economic pressures.

The concern with the means of restoration of form has continued unabated and with enthusiasm over the years. These methods have included astragalectomy, pounding with a mallet, stretching on racks, using pins of various sizes in any and all directions, followed by rigid immobilization in plaster. The culmination of these procedures is the ultimate, and probably logical, measure of Pridie's procedure—complete excision of the calcaneus. We have only to wait for the first replacement prosthesis.

The conservative approach is not new. N. W. Roberts of Liverpool and W. S. Creer, working independently in 1947, attempted early ankle and foot motion without any reduction of the fracture and without weight-bearing. The better results following spinal fractures treated by early active mobilization after the fashion of Magnus was, undoubtedly, a stimulus. Long periods of hospitalization and avoidance of weight-bearing were employed. In 1951, Bertelsen and Hasner reported using a "foot-free walking bandage" in the treatment of all fractures of the calcaneus.

In this discussion, we are primarily concerned with fractures involving the subtalar joint. As we have pointed out, it appears hopeless, as well as technically impossible, to attempt to restore accurately a normal articular surface to a subtalar joint which has been disrupted. We believe that there are other factors which are as important to be considered in the choice of treatment.

1. *The weakening of the gastrocnemius mechanism*, as a result of widening and shortening of the calcaneal attachment, and atrophy of disuse from prolonged immobilization. The resulting disability is a marked weakness and reduction in the ability to plantarflex the foot. These patients are then unable to shift their weight forward and thus alter subtalar stress.

2. *Rigidity in the other joints of the foot.* This is secondary to long immobilization and disuse. The fibroblastic adhesions and thickening of the capsular elements which develop are responsible for much of the disability.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1954. Revised manuscript received for publication January 13, 1955.

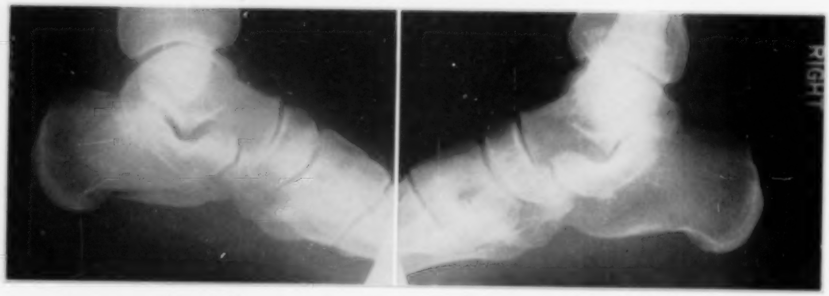

Fig. 1-A

Fig. 1-B

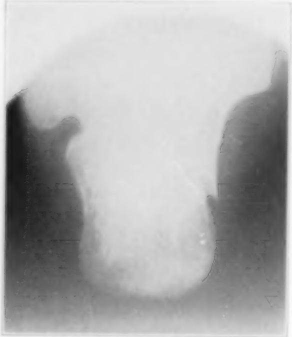

Fig. 1-C

Case No. 18094, refinery worker. Lateral and postero-anterior roentgenograms of a left foot (Figs. 1-A and 1-C) and lateral roentgenogram of the normal right foot (Fig. 1-B) for comparison, showing fracture of the body of the left calcaneus into the subtalar joint with loss of tuber angle. The foot was immobilized in the equinus position in a walking cast for five and one-half weeks. The patient returned to work after nine weeks.

3. *Traumatic tenosynovitis* in the long peroneal tendons at the ankle. The lateral spreading of the calcaneus results in their impingement against the lateral malleolus and the fixation of the tendons in their tunnels. This condition is aggravated by the use of clamps and mallets.

4. *Rupture of the fibrous septa* and their fat-filled compartments in the soft tissues over the plantar surface of the calcaneus destroys this system of hydraulic buffers for efficient and painless weight-bearing [10]. Long immobilization, the use of pins in the area, and inactivity favor fibrosis and delay restoration of these structures.

## PRINCIPLES

The primary principles of our method are to keep the musculotendinous structures in an advantageous position for maintaining their mobility and tone and to permit early function of the foot and ankle structures other than the calcaneus and the subtalar joint. We maintain muscle tone by immobilizing the slightly everted foot in an equinus walking position with the heel protected by a large sponge-rubber pad. This position shortens the gastrocnemius, carries the body weight distally to the metatarsus and the ground, and places the peroneal tendons in a functional position. The lateral groove for these tendons is enlarged when the foot returns to the neutral position. Early weight-bearing in plaster maintains circulatory exchange and muscle tone, and early removal of the cast and raised-heel weight-bearing prevent impairment of joint activity.

## PROCEDURE

While the principles of treatment remain the same, the exact sequence of treatment will vary with different circumstances.

1. In treating patients seen within a few hours of an injury which is uncomplicated, the procedure is as follows:

a. Immediate immobilization, after gentle molding of the heel with the hands, in a short plaster leg cylinder with the foot in the maximum equinus position and well padded about the heel with sponge rubber (Fig. 3-A). Sedation with morphine at times is required.

b. A rubber walking heel is fixed to the plaster at the level of the metatarsal heads (Fig. 3-B).

c. Part-time elevation and part-time light weight-bearing with crutches, the patient touching the walking heel to the floor for balance.

d. Full weight-bearing as soon as tolerated.

e. Removal of all fixation in six weeks.

f. Full weight-bearing with shoe, the heel of which is raised one and one-half inches. Barefoot walking on the ball of the foot.

g. Gradual lowering of the heel to the normal position over the succeeding six to eight weeks.

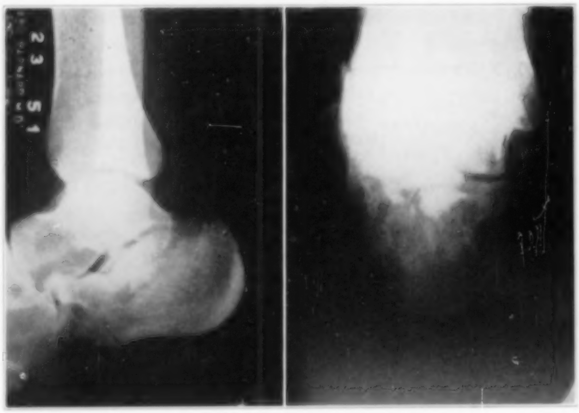

Fig. 2

Case No. 18087, butcher. Lateral and postero-anterior roentgenograms of fractured calcaneus with marked disruption of subtalar joints. Original duration of treatment was twelve weeks. Two years later, the patient required an additional surgical procedure to remove the lateral mass beneath the malleolus. This was the only case requiring further surgery.

2. When the patient is not seen within the first few hours and severe swelling has intervened, or when there are complications, such as fracture of the spine, the procedure is as follows:

a. Absolute bed rest with the feet elevated; the equinus position is automatically assumed.

b. Active exercises of the foot, ankle, and toes are carried out hourly when the patient is awake.

c. When the swelling has subsided sufficiently and ambulation is possible, the procedure is begun as in patients seen immediately after injury (1).

### ANALYSIS OF CASES

Of the group studied, the average age was 48.75 years, the oldest patient being eighty and the youngest twenty-three. The average period of immobilization, during which the patients were ambulatory in walking casts, was 6.5 weeks. The average period of disability in nineteen cases was 13.7 weeks.

The group comprised twenty patients and twenty-two fractures of the calcaneus.

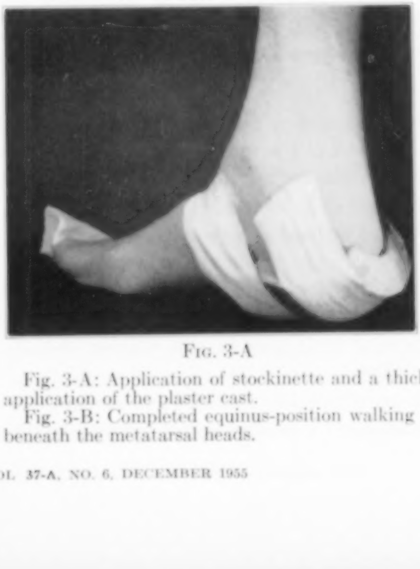

Fig. 3-A

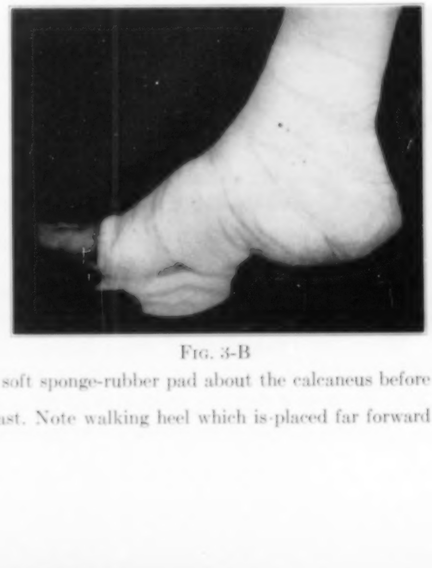

Fig. 3-B

Fig. 3-A: Application of stockinette and a thick soft sponge-rubber pad about the calcaneus before application of the plaster cast.

Fig. 3-B: Completed equinus-position walking cast. Note walking heel which is placed far forward beneath the metatarsal heads.

## TABLE I

### STATISTICAL ANALYSIS OF CASES

| Case No. | Sex | Age | Period before Return to Work (*Weeks*) | Degree of Subtalar Widening * | Gastrocnemius Function (Tip-toe Walk) † | Occupation | Duration of Immobilization (*Weeks*) | Associated Injuries |
|---|---|---|---|---|---|---|---|---|
| 15419 | F | 53 | 9 | + | + + + + | PBX operator | 5.5 | Superficial, multiple |
| 16002 | F | 80 | 6 | + + | + | Pensioner | 6 | None |
| 16351 | M | 39 | 17 | + + + | + + + | Bartender | 8.5 | None |
| 16355 | F | 35 |  | + + + | + + | Housewife | 11 | Acetabulum, left tarsal navicular |
| 16548 | F | 50 | 6 | + | + + + | Housewife | 4 | None |
| 17400 | M | 45 | 13 | + + | + + + | Machinist | 8.5 | Patella |
| 17960 | M | 60 | 18 | + + + | + + | Watchman | 7 | None |
| 18087 | M | 49 | 12 | + + + | + + | Butcher | 5.5 | None |
| 18094 | M | 62 | 9 | + + | + + | Refinery worker | 5.5 | None |
| 18262 | F | 23 | 8 | + | + + + | Stripper in cannery | 4 | None |
| 19066 | F | 35 | 9 | + + | + + | Cook | 5 | Fractures of knee, wrist |
| 19221 | M | 50 | 23 | + + + | + | Carpenter | 11.5 | None |
| 19361 | M | 35 | 45** | L, + + +<br>R, + + | L, +<br>R, + + | Iron worker | 8 | Fractures of back, wrist |
| 19427 | F | 40 | 6 | + + | + + + | Nun | 4.5 | None |
| 20347 | F | 49 | 9 | + + | + + + | Housewife | 5.5 | None |
| 20433 | M | 55 | 10 | + | + + | Gardener | 4.5 | None |
| 20468 | M | 73 | 12 | + + + | + + | Painter | 5 | Fracture of olecranon |
| 20537 | M | 57 | 18 | + + | + | Electrician | 5 | None |
| 17800 | M | 28 | 22 | + + | + + + | Roofer | 9 | Fracture of spine |
| 20398 | M | 57 | 23 | L, + +<br>R, + + + | L, + +<br>R, + | Painter | 7 | None |

* The degree of subtalar widening is indicated on the scale 0 to + + + + in which 0 represents no deformity and + + + + indicates maximum spreading. No patient was completely free of deformity.

† In the evaluation of gastrocnemius function, as reflected in the ability to walk on tip toe, 0 represents complete loss and + + + + indicates normal function. In no patient was there complete loss of gastrocnemius function.

** This patient did not return to former employment, but does light work and has surprisingly good function of feet and ankles.

One patient who had bilateral fracture of the calcaneus, a compression fracture of the spine, and a comminuted fracture of the distal portion of the radius received a *permanent rating*,—that is, he did not return to his former employment but he is at present doing light work with surprisingly good function of feet and ankles. In one case, surgical excision of the lateral mass was required after the patient had worked at his regular job as a butcher for over two years (Fig. 2).

All patients have been followed for a period of at least one year and not more than three.

Objective evaluation of these injuries following treatment in this manner reveals a foot in moderate equinovalgus position, a definite widening of the subtalar area laterally, and in all cases a definite weakness of the gastrocnemius, but still efficient function.

The best results were obtained in patients who had a greater loss of subtalar motion, or better stability. Anatomically, it would appear that the slight equinovalgus position finally obtained in the foot afforded a more stable and efficient weight transmitter than the position of the foot in which the so-called tuber angle had been restored and maintained. The flattened, somewhat everted foot, with the shortened gastrocnemius, contributes to the lateral stability and maintains a relatively normal width between the external malleolus and the lateral mass, and this does not interfere with peroneal function.

It is our belief that symptoms in the peroneal tunnels laterally are the result of repeated trauma from an unstable subtalar joint as well as the spreading of the fragments of the calcaneus. When the foot is first put into the equinus position for application of the cast, these fragments are forced distally, resulting in a widening of the space which is maintained when the foot returns to a neutral position.

Those patients who sustained serious injury as a direct result of their occupations, that is, the roofer, the ironworker, and others, did not return to their former occupations, at least as far as we know. It is possible that the other associated injuries may well have been the reason for this. All of the patients complained of some mild pain in the subtalar area on long standing or after activity, and all were dependent on firm shoeing.

As no attempt was made to correct the anatomical deformity, the end results from this viewpoint were poor.

## SUMMARY

A method for the conservative treatment of fractures of the calcaneus has been used in a series of cases. The number of patients is small, but each has had an adequate follow-up, and these patients are a representative group. The results so far are encouraging.

While we do not feel that subtalar arthrodesis should be completely abandoned, we believe that it will rarely be required.

## REFERENCES

1. Bertelsen, Arne, and Hasner, Eivin: Primary Results of Treatment of Fracture of the Os Calcis by "Foot-Free Walking Bandage" and Early Movement. Acta Orthop. Scandinavica, **21:** 140–154, 1951.
2. Böhler, Lorenz: Behandlung der Fersenbeinbrüche. Chirurg, **1:** 733–737, 1929.
3. Condit, L. I.: Fractures of the Os Calcis. Surg., Gynec., and Obstet., **42:** 133–134, 1926.
4. Conn, H. R.: The Treatment of Fractures of the Os Calcis. J. Bone and Joint Surg., **17:** 392–405, Apr. 1935.
5. Cotton, F. J.: Fractures of the Os Calcis. Boston Med. and Surg. J., **159:** 559–565, 1908.
6. Cotton, F. J.: Old Os Calcis Fractures. Ann. Surg., **74:** 294–303, 1921.
7. Goff, C. W.: Fresh Fracture of Os Calcis. Arch. Surg., **36:** 744–765, 1938.
8. Goff, C. W.: Closed Reduction of Fractures of the Os Calcis. New England J. Med., **216:** 293–298, 1937.
9. Harding, M. C.: Os Calcis Fractures: A New Method of Reduction. J. Bone and Joint Surg., **8:** 720–722, Oct. 1926.
10. Harris, R. I.: Fractures of the Os Calcis. *In* Instructional Course Lectures, The American Academy of Orthopaedic Surgeons, 1952. Vol. 9, pp. 375–379. Ann Arbor, J. W. Edwards, 1952.
11. Hermann, O. J.: Conservative Therapy for Fracture of the Os Calcis. J. Bone and Joint Surg., **19:** 709–718, July 1937.
12. Jaekle, R. F., and Clark, A. G.: Fractures of the Os Calcis. Surg., Gynec., and Obstet., **64:** 663–672, 1937.
13. Magnus, Georg: Zur Behandlung der Wirbelbrüche. Arch. f. Klin. Chir., **191:** 547–556, 1938.
14. Olson, P. F.: The Treatment of Fractures of the Os Calcis. J. Bone and Joint Surg., **21:** 747–751, July 1939.
15. Pridie, K. H.: A New Method of Treatment for Severe Fractures of the Os Calcis. A Preliminary Report. Surg., Gynec., and Obstet., **82:** 671–675, 1946.
16. Roberts, N. W.: Personal communication, 1952.
17. Roberts, N. W., and Creer, W. S.: News Notes of Annual Meeting of British Orthopaedic Association. Lancet, **1:** 65, 1947.

## DISCUSSION

Dr. Robert Lee Patterson, New York, N. Y.: In discussing the paper given by Dr. Barnard and Dr. Odegard on the conservative method of treatment of fractures of the calcaneus, one certainly can say that the approach is not new. I remember quite well that, in 1942, at a meeting of the Consultants in the European Theater of Operation, Mr. Furlong tried to convince Brig. Gen. Bristow that fractures of the calcaneus should be treated simply as injuries of the soft parts, with early function and early motion without weight-bearing. This was due to the fact that, when a man sustained a fracture involving the subtalar joint, he did not return to full duty. If my memory serves me right, the type of treatment which was recommended by Mr. Furlong did not allow these soldiers to return to duty as infantrymen.

Probably the most significant statements made by Dr. Barnard concerned the relationship of the soft parts to the injury sustained when the calcaneus is fractured. Certainly, after triple arthrodesis, whether it is performed as a primary procedure or later, the results are not always good,—in fact, far from it. It is not because there is any pain from the fused subtalar joints but because there is a tremendous degree of pain on the plantar surface of the heel in prolonged standing or in walking.

It is unfortunate that Dr. Barnard did not give us a description of the cases, that he did not discuss in what percentage of patients the articular surfaces were depressed, what percentage of patients had residual symptoms as a result of injury. It is, of course, true that all but one of the patients treated by his method returned to some regular occupation. But, again, it would have been extremely interesting to have seen the original roentgenograms and those made as much as three years later, in order to determine what changes had taken place in the subtalar or mid-tarsal joints when feet are treated in this conservative way.

I should think that this method of treatment of Dr. Barnard's would have a definite application in those patients who sustain other severe injuries which make operative intervention impossible. Even though there have been numerous methods recommended for the treatment of fractures of the calcaneus, I think that we as orthopaedic surgeons should treat this joint as we do any other joint in which there has been a disruption of the articulating surfaces—that is, by either anatomical replacement or elimination of motion.

DR. BARNARD (closing): My idea in presenting this paper was to emphasize that there are ways of treating fractures of the calcaneus other than by the use of knives, chisels, pins, and metallic instruments. I think that maybe once in a while this should be recalled to us. I'm sorry that Dr. Patterson didn't see any of these movies and some other roentgenograms that I probably should have sent to him. All of these patients had comminuted fractures of the calcaneus impacted into the talocalcaneal joint.

# RESIDUAL DISABILITY FOLLOWING ACUTE ANKLE SPRAINS*

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*From the Hitchcock Clinic and Hitchcock Foundation, Hanover*

The immediate disability resulting from acute ankle sprains is readily appreciated by physicians who have had the responsibility for treatment of these injuries. Indeed, during the acute phase of the injury, the patient may be totally incapacitated. Because of the severe pain and disability associated with the acute phase of an ankle sprain, most of the attention of those interested in this condition has been directed toward the alleviation of pain and a return to full activity in as short a time as possible. The success of such treatment has usually been measured in terms of duration of disability following the acute injury. Probably because of this emphasis there has been little study of the eventual outcome in ankles which have sustained an acute sprain. We have attempted to carry out such a study, the results of which are reported here.

The mechanism of the acute injury is relatively constant. In the majority of cases, the injury occurs when the foot is inverted, and the sprain is limited to the external lateral ligament of the ankle. The ligament consists of three fasciculi. It is commonly accepted that the anterior and middle fasciculi (anterior talofibular and calcaneofibular ligaments) are torn to a variable degree but that the posterior fasciculus (posterior talofibular ligament) is rarely injured. The injured portion of the ligament may be completely torn across, or there may be only a partial tearing or stretching. In addition, there may be an extravasation of blood into the surrounding tissues, more or less effusion into the joint with some degree of synovitis, and a variable amount of stretching of the peroneal muscles and soft tissues on the lateral aspect of the ankle. Leriche, however, has proposed that the pain in great part is due to a combination of irritation of nerve endings in the joint capsule and ligaments and reflex vascular changes.

## MATERIAL

Situated as we are in a college community where there is more than the usual interest in sports which predispose to injury, we have had the opportunity to treat many ankle sprains. In the course of this experience, we were impressed with what seemed to be a high incidence of persistent, although not often severe, changes following this injury. With the student patients and the facilities of the Dartmouth College Infirmary at our disposal, we have been able to study the incidence of disability following ankle sprain in two graduating classes.

The charts for all students in the classes of 1953 and 1954 who had been treated for an ankle sprain during their college career were analyzed for details of the injury and treatment. During the month preceding their graduation, an effort was made to have these students return for a follow-up examination.

At the time of graduation, these classes were comprised of 1,120 students. A total of 148 patients from the two classes were treated for 177 ankle sprains. During the month prior to graduation, 113 patients (76 per cent.) were examined, giving a follow-up of 133 sprains (76 per cent.). From one class, seventy-six patients (96 per cent.) were followed, but only thirty-seven patients (53 per cent.) from the other, giving an over-all follow-up of 75 per cent. The mean time between acute injury and follow-up examination was twenty-nine months; the shortest follow-up was two months; the longest forty-five months.

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* Presented in part at The Boston Orthopaedic Club, Boston, Massachusetts, April 26, 1954.

These 113 patients with 133 ankle sprains who returned to a follow-up examination were surveyed statistically. A history of previous ankle sprain was given by forty-eight patients (42 per cent.). Most patients reported that this had occurred prior to entering college; in a few cases, the previous injury had occurred while at college and the student had elected not to report it, either having received no treatment or having treated the sprain himself.

The right ankle was involved in seventy-nine injuries and the left in forty-eight injuries; 5 per cent. or six of the injuries were bilateral. In this group, there were fourteen patients with recurrent injuries.

### *Etiology*

The major activities at the time of injury were, in order of incidence, skiing, football, and basketball. While the high incidence of injuries from skiing would seem to indicate that it might be more dangerous from this standpoint than any other activity, closer examination does not bear this out; skiing is engaged in by far more students than any other activity except basketball. In addition, one or two injuries occurred during each of the following sports: baseball, skating, volleyball, track, soccer, swimming, lacrosse, hiking, golf, and hockey.

### *Roentgenographic Findings*

Roentgenographic examination of the injured ankle had been made in 121 instances (90 per cent.) at the time of the acute injury. In the remaining twelve instances (10 per cent.), the diagnosis had seemed so definite clinically that roentgenograms had not been made. However, at the time of follow-up, roentgenograms were obtained in all of these cases, and there was no evidence that there had ever been a fracture. Five patients showed evidence of cortical avulsion fractures of the talus. These were also classified as sprains. Four showed evidence of old injuries of a similar nature. If, at the time of injury, there had been a question of a major injury to the ankle ligaments, roentgenographic examination was made with both ankles held in inversion. When these inversion roentgenograms demonstrated widening of the ankle-joint mortise or subluxation of the talus, the injury had been classified as a dislocation and was not included in the series. In the course of such special roentgenographic examination, eleven such injuries were diagnosed in patients who were members of the two college classes with which this report is concerned; these patients were excluded from the series. Included in this series are thirty-two patients (24 per cent.) who were diagnosed as having possible dislocations but whose roentgenograms, made of both ankles in inversion, proved to be negative.

### *Treatment*

As a general policy, our treatment did not include the use of procaine injection, ethyl chloride spray, or similar methods of relieving pain directed toward very early return to activity. The therapy we have employed has been principally bed rest, physical therapy, the use of crutches, adhesive strapping, and elastic bandaging.

Hospitalization was necessary in twenty-six patients (23 per cent.). They were admitted to the college infirmary for an average stay of four days. The shortest stay was two days, the longest seventeen days. The reason for these admissions in most cases was that the students could not adequately care for themselves in their dormitories. Eight of the twenty-six admitted to the infirmary showed evidence of severe vasospasm secondary to their injury and received one or more blocks to the lumbar sympathetic trunk.

Some form of physical therapy was given to sixty-eight patients (51 per cent.). The methods employed were whirlpool baths, hot packs, hot soaks, dry heat, and, in the initial stages, ice packs.

Crutches had been used in seventy-two injuries (54 per cent.) for an average period of nine days; the shortest period was three days, the longest twenty-one days. Adhesive strapping of the Gibney type had been used for immobilization of the ankle in twenty-six of the 133 sprains; in these, the ankles had been strapped for an average period of thirteen days. Sprains had been treated by elastic bandages for an average of thirteen days in 100 sprains (75 per cent.). The elastic bandages had frequently been used after the adhesive strapping had been discontinued. A walking cast had been employed for immobilization in four cases, because these patients, after a period of bed rest and physical therapy, had shown less than the usual response to therapy and persistence of severe symptoms. The casts had been applied in order to provide complete rest to the injured structures while permitting a return to partial activity. It is of interest that statistically there was no correlation between the type of treatment and the incidence of persistent disability.

### *Disability*

Twenty-seven patients (24 per cent.) resumed the activity at which they were injured or some comparable activity before they were free of symptoms from the injury.

The convalescent period for the entire series averaged thirty-three days from the date of injury until return to full activity.

## THE FOLLOW-UP EXAMINATION

At the time of the follow-up examination prior to graduation, thirty-seven patients (33 per cent.) complained of ankle symptoms, while sixty-eight patients (60 per cent.) presented abnormal physical findings. The symptoms varied from occasional recurrent sprains on strenuous activity to instability of the ankle on walking, especially if loose stones or uneven ground were encountered. These same patients complained of varying degrees of pain, ordinarily not severe.

The abnormal physical signs elicited at the time of the follow-up visit were found as the result of a very critical local physical examination. All patients with questionable findings in regard to stability or strength were examined by at least two of the authors, and in the whole series only thirteen of the patients were seen by only one examiner. If the evaluation of the signs was not agreed upon by two or more examiners, such findings were not recorded. In addition to the determination of the presence or absence of tenderness and swelling, the range of motion was determined and the stability and strength were evaluated.

### *Tests for Ankle Stability*

The degree of lateral motion of the talus in relation to the tibia was determined in two ways: first, by testing for an abnormal inversion range of the talus in the ankle-joint mortise, and, second, by estimating the medial and lateral play of the talus in relation to the tibia. Because of the great individual variation in the stability of the ankle, the affected ankle was compared with that of the opposite side; in questionable cases, the patient was routinely checked by a second examiner as well.

To test inversion stability, the foot was held in approximately 40 degrees of plantar flexion and was manually inverted, the leg being fixed by the examiner's other hand. While this was done, the examiner placed a finger of the supporting hand over the anterolateral aspect of the talus. In this way, not only the total inversion of the foot and ankle could be determined, but also the amount of separation of the talus from the tibia could be estimated. Patients who had more than minor changes of the excursion of the talus and more than 15 degrees of increased total inversion of foot and ankle were excluded from this group of patients as belonging to the dislocation group.

The extent of lateral and medial play of the talus in the ankle-joint mortise was tested with the patient in the supine position. The supramalleolar region was firmly

TABLE I

ABNORMALITIES OF MOTION IN 133 SPRAINS*

| Type of Motion | Range of Motion Increased (*No. of Cases*) | Range of Motion Decreased (*No. of Cases*) |
|---|---|---|
| Dorsiflexion | 4 | 6 |
| Plantar flexion | 4 | 5 |
| Inversion | 20 | 3 |
| Eversion | 10 | 3 |
| Lateral and rotary mobility of talus in ankle-joint mortise | 55 | |

* These abnormalities occurred in eighty cases (71 per cent.).

held by one of the examiner's hands and the heel was firmly held by the other hand. The heel was then pushed medially and laterally, in order to determine the lateral play of the heel in relation to the distal portion of the tibia and the fibula. To determine that this play involved the talus rather than the talocalcaneal joint or distal tibiofibular articulation, the anterolateral aspect of the talus was palpated and the amount of excursion of the structure was estimated. Again, the opposite ankle was tested for comparison. In no patients of the groups were gross changes of this sort elicited.

To determine the inversion-eversion strength manually, the examiner fixed the lower end of the leg with one hand and grasped the mid-metatarsal area of the foot held in 40 degrees of plantar flexion with the other, holding it firmly so as to resist excursion of the foot. Strength was tested in two ways: first, by estimating the manual force exerted by the examiner to prevent active inversion or eversion and, second, by estimating the force exerted to "break" the foot from the position of full, sustained, active inversion or eversion. The results were routinely compared with those of the opposite side. In all cases the differences in strength were minor, and the injured ankle was never given less than a *good* rating.

### *Residual Disabilities*

A review of the results of these examinations (Table I) revealed that over two-thirds of the total number of cases in the series had changes in ankle-joint motion and that the majority of these changes were increases in the range of motion, particularly in inversion and eversion (Table I). Abnormal lateral and rotatory mobility of the talus in the ankle-joint mortise was present in fifty-five cases (41 per cent.). With this large number of cases exhibiting some degree of excessive mobility, one might wonder whether these particular patients should have been diagnosed originally as having ankle subluxation or dislocation, rather than sprain. This is unlikely because, first, student patients with ankle injuries in this community are seen early even when the injuries are not severe, and they are hospitalized much more commonly than is usual,—consequently, they are closely observed. Second, if there is any question of dislocation or subluxation, special inversion roentgenograms are made. In addition, it must be mentioned once again that the changes found on follow-up examination were not marked and not great enough to be measurable by special roentgenographic examination.

It was interesting to find that relative weakness of the peroneal muscles as determined by manual examination was present in twenty-nine cases (22 per cent.). Tenderness, usually over the soft tissues adjacent to the lateral malleolus, was present in ten cases (7 per cent.). Soft-tissue swelling was observed in thirty-one cases (23 per cent.).

TABLE II

ABNORMALITIES OF MOTION IN FORTY-FOUR SPRAINS WITH SYMPTOMS

| Type of Motion | Range of Motion Increased (*No. of Cases*) | Range of Motion Decreased (*No. of Cases*) |
|---|---|---|
| Dorsiflexion | 4 | 1 |
| Plantar flexion | 4 | 1 |
| Inversion | 12 | 2 |
| Eversion | 6 | 1 |
| Lateral and rotary mobility of talus in ankle-joint mortise | 29 | |

### DISCUSSION

It is immediately apparent from the results of the follow-up examination that the patients with abnormal findings on physical examination outnumber those with subjective symptoms approximately two to one. In correlating these two groups statistically, it was found that thirty-five cases (43 per cent.) of those injuries with residual changes (eighty cases) also had ankle symptoms. A group of nine patients had ankle symptoms without abnormal physical findings,—for which there is no obvious explanation.

In an effort to determine why 57 per cent. (forty-five cases) of the group with abnormal changes did not have ankle symptoms, as well as to determine what factor or factors were important in producing residual disability, the various groups were compared with each other and with the entire group with reference to (1) the several types of treatment, (2) whether or not there was return to activity prior to becoming symptom-free, (3) the average number of days prior to return to full activity, and (4) previous injuries. This analysis of the interrelationship of these various factors failed to demonstrate any statistically significant * difference which might account for the persistence of ankle symptoms or of abnormal physical findings. Continuing this analysis, no type or types of abnormal mobility were significantly associated with the group of symptoms (Table II).

When the factor of peroneal muscle weakness was brought into the comparison, however, it was statistically significant *. Of the thirty-five injuries with both residual changes and ankle symptoms, twenty-three (66 per cent.) had peroneal muscle weakness. Six other patients with peroneal muscle weakness had no ankle symptoms.

In the group of fifty-five patients (41 per cent. of the entire series) with increased lateral mobility or rotary motion of the talus in the ankle-joint mortise, twenty-nine (52 per cent.) had ankle symptoms. Twenty (69 per cent.) of this twenty-nine had peroneal muscle weakness (Table III).

TABLE III

RELATION OF INCREASED MOBILITY OF TALUS IN ANKLE-JOINT MORTISE TO PERONEAL MUSCLE STRENGTH IN 133 SPRAINS

| Talar Mobility and Peroneal Muscle Strength | No. of Cases | |
|---|---|---|
| Increased mobility of talus in ankle-joint mortise | | 55 |
| Normal peroneal muscle strength | | 31 |
| Without symptoms | 22 | |
| With symptoms | 9 | |
| Peroneal muscle weakness | | 24 |
| Without symptoms | 4 | |
| With symptoms | 20 | |

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* Chi square formula.

The mechanism of this muscular weakness is not readily apparent. Our results indicate that it is not due to the length of immobilization. Hyslop has reported three cases of ankle sprain in which there was a similar prolonged peroneal muscle weakness. He has attributed this to some degree of paralysis of the deep and superficial peroneal nerves subsequent to sudden tensing and stretching of the nerve over the neck of the fibula at the time of the injury. This theory in turn suggests the possibility that the weakness may be due merely to overstretching or disuse of the muscles themselves. We are more inclined to accept this possibility.

It is important to stress the fact that the residual symptoms which we have mentioned have not been incapacitating and that in only very few cases have the patients sought treatment for them. On the other hand, recovery from the injury had not been complete and the symptoms ranged from being merely annoying to limiting some activity. Kurtz has mentioned similar symptoms, describing the more severe cases as frequently "tripping over the flowers in the rug."

In correlating the results of this survey, two interesting findings appeared. First, residual disability and abnormal physical signs, although usually not severe, were much more common than we had anticipated; and, second, in correlating the various possible causative factors in persistent disability, peroneal muscle weakness appeared to be statistically the most significant factor.

The common finding of abnormal mobility of the talus in the ankle-joint mortise and peroneal muscle weakness (if it is a constant finding as more patients are examined) poses the question: Is it more important to provide more careful fixation initially to prevent subsequent ligament relaxation or to stress early active use to prevent, if possible, peroneal weakness? We are not in a position to answer this. However, in the later stages, it is logical to increase peroneal muscle strength by resistive exercises, which Coltart has mentioned; and on the basis of the authors' study it would seem, at this point, that resistive exercises for the peroneal group of muscles would be a reasonable method of treatment to apply to those patients having residual symptoms following ankle sprains.

After completing the study of the class of 1953, the importance of a more objective method of evaluating the peroneal muscle strength was appreciated. In an effort to accomplish this, we developed several modifications of an apparatus originally designed (by Osgood) for testing the comparative strength of the adductor and abductor groups in the foot. Our apparatus was based on the principle of fixing the leg in a splint and pulling against either a spring balance or a weight by inverting or everting the foot. Theoretically, this would permit a quantitative measurement of the strength of the respective muscles and a comparison between patients, as well as between both ankles in the same patient. In practice, the apparatus proved unsatisfactory despite numerous modifications. The majority of difficulties were caused by variations in motivations of the patients and by the ability of some patients to develop skill in the use of the apparatus, often by using muscle groups in the thigh. Consequently, peroneal strength in both classes was tested manually and we are still searching for a more objective method.

As a result of these studies, we are impressed with the incidence of residual disability from acute ankle sprains and with the need for a therapeutic program to prevent and correct such disabilities. Further studies along these lines are planned.

## SUMMARY

1. A series of 133 ankle sprains with an average follow-up of twenty-seven months has been studied for residual disability subsequent to the injury.

2. There was a 36 per cent. incidence of previous injury to the same ankle.

3. Residual ankle symptoms were found in 33 per cent. of the patients, and persistent abnormal changes of the ankle were found in 60 per cent.

4. The only statistically significant factor found among those who had chronic ankle symptoms was a high incidence of peroneal muscle weakness.

REFERENCES

1. Coltart, W. D.: "Sprained Ankle". British Med. J., **2**:957–961, 1951.
2. Hyslop, G. H.: Injuries to Deep and Superficial Peroneal Nerves Complicating Ankle Sprains. Am. J. Surg., **51**: 436–438, 1941.
3. Kurtz, A. D.: Chronic Sprained Ankle. Am. J. Surg., **44**: 158–160, 1939.
4. Leriche, René, and Arnulf, G.: Treatment of Sprains by Interligamentary Injection of Novocaine. Am. J. Surg., **32**: 45–47, 1936.
5. Osgood, R. B.: The Comparative Strength of the Adductor and Abductor Groups in the Foot. A Foot Exerciser. Am. J. Orthop. Surg., **5**: 298–303, Jan. 1907.

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# THE INCIDENCE OF SCOLIOSIS IN THE STATE OF DELAWARE

## A Study of 50,000 Minifilms of the Chest Made During a Survey for Tuberculosis *

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In the fall of 1953, 194,060 chest roentgenograms were made in the State of Delaware during a survey for pulmonary tuberculosis. This number represented 82.2 per cent. of the population over fourteen years of age. Of these roentgenograms, 173,151 were made by mobile x-ray units on 350 to 400 exposure rolls of 70 millimeter x-ray film. The authors examined 50,000 of the minifilms, in 936 of which they found evidence of scoliosis. The films showing scoliosis were analyzed according to (1) the sex, race, and age of the subject and (2) the magnitude of the curve and the direction and level of its apex. In addition, an attempt was made to determine the etiology of the curvatures which appeared in the first 15,000 films examined.

In recording the amount of curvature, the Cobb technique was used to measure the angle of the curve. Curves with angles between 10 and 19 degrees were recorded as mild; those with angles between 20 and 29 degrees, as moderate; and those with angles over 30

TABLE I

Incidence of Scoliosis in 50,000 Persons in Delaware over Fourteen Years of Age

| | No. | Per cent. |
|---|---|---|
| Total Number of Cases | 936 | |
| No. per 1000 | 19 | 1.9 |
| No. per 1000 with mild curves (10°–19°) | 14 | 1.4 |
| No. per 1000 with moderate curves (20°–29°) | 3 | 0.3 |
| No. per 1000 with severe curves (30° or more) | 2 | 0.2 |

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* Presented at the Meeting of the International Society of Orthopaedic Surgery and Traumatology, Berne, Switzerland, August 1954.

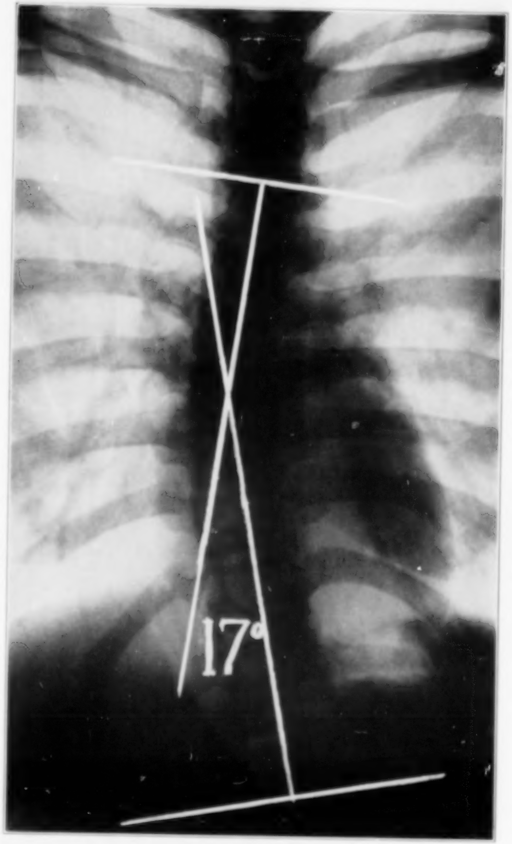

Fig. 1

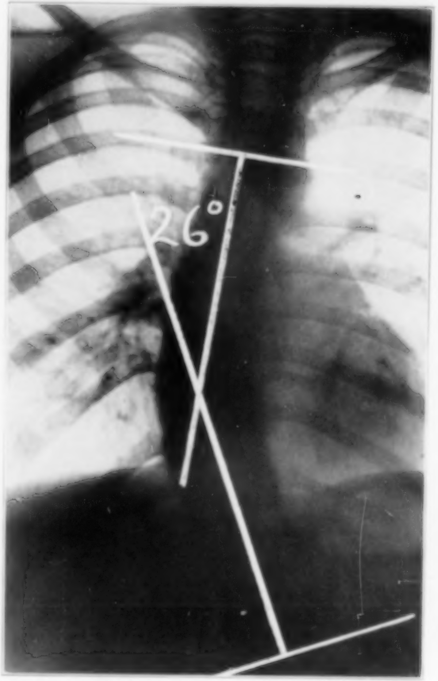

Fig. 2

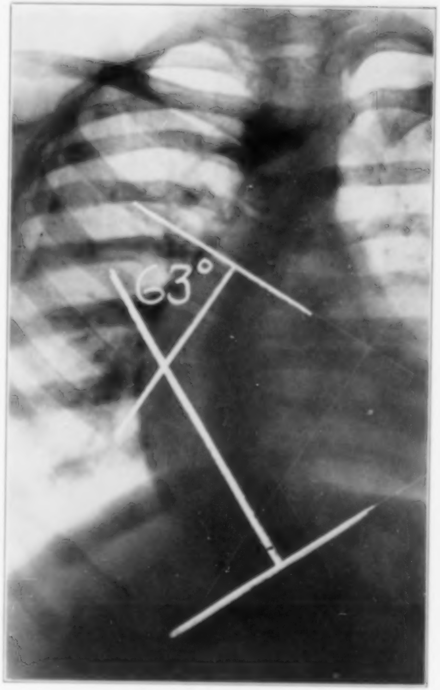

Fig. 3

Figs. 1, 2, and 3: Chest roentgenograms showing mild, moderate and severe curves. In recording the amount of curvature, the Cobb technique was used to measure the angle of the curve.

Fig. 1: Curves with angles between 10 and 19 degrees were recorded as mild.
Fig. 2: Curves with angles between 20 and 29 degrees were recorded as moderate.
Fig. 3: Curves with angles over 30 degrees were recorded as severe.

TABLE II

SEX DISTRIBUTION OF 936 PERSONS WITH SCOLIOSIS

| Degree of Curvature | Male (No.) | Male (Per cent.) | Female (No.) | Female (Per cent.) | Total (No.) | Total (Per cent.) |
|---|---|---|---|---|---|---|
| Mild (10°–19°) | 166 | 73.1 | 538 | 75.9 | 704 | 75.2 |
| Moderate (20°–29°) | 35 | 15.4 | 98 | 13.8 | 133 | 14.2 |
| Severe (30° or more) | 26 | 11.5 | 73 | 10.3 | 99 | 10.6 |
| Total | 227 | 100.0 | 709 | 100.0 | 936 | 100.0 |

Ratio among persons with scoliosis Male: Female:: 24.3: 75.7
Ratio in Delaware population Male: Female:: 48.9: 51.1
Rate per 1000: Male — 9.3
Female — 27.7

degrees, as severe (Figs. 1, 2, and 3). No curvature in which the angle was less than 10 degrees was recorded.

The incidence of scoliosis was found to be nineteen per 1000, or 1.9 per cent. (Table I). The number of mild curves was fourteen per 1000, or approximately three times the combined number of moderate and severe curves. The number of mild curves represented 75.2 per cent. of the total number of curves; the number of moderate, 14.2 per cent.; and the number of severe, 10.6 per cent. (Table II).

In the analysis of the data according to sex (Table II), it was found that 227 of the subjects were males and 709 females. The rate per 1000 was 9.3 for the males and 27.7 for the females, a ratio of approximately one to three. The total number of moderate and severe curves in the males was 2.8 per cent. higher than the total number in the females.

In the analysis of the material according to race (Table III), it was found that the rate per 1000 was 20.6 for the Negro and 18.4 for the white, not a significant difference. The total number of moderate and severe curves in the negro was 9 per cent. higher than the total number in the white, a significant difference.

An analysis of the material according to age (Table IV) showed that the highest incidence of scoliosis occurred among subjects fifteen to nineteen years of age; the rate for this group was 31.2 per 1000. In the group fifty to fifty-nine years of age the rate dropped to 14.8 per 1000, but in the group seventy years of age or over it went up again to 21.2 per 1000. The percentage of mild curves was higher (86.6 per cent.) in the group

TABLE III

RACE DISTRIBUTION IN 936 PERSONS WITH SCOLIOSIS

| Degree of Curvature | White (No.) | White (Per cent.) | Negro (No.) | Negro (Per cent.) |
|---|---|---|---|---|
| Mild | 608 | 76.6 | 96 | 67.6 |
| Moderate | 108 | 13.6 | 25 | 17.6 |
| Severe | 78 | 9.8 | 21 | 14.8 |
| Total | 794 | 100.0 | 142 | 100.0 |

Ratio among persons with scoliosis White: Negro:: 84.8: 15.2 (794) (142)
Ratio among 50,000 persons whose minifilms were examined White: Negro:: 86. 2:13.8 (43,100) (6,900)
Rate per 1000: White — 18.4
Negro — 20.6

TABLE IV

AGE DISTRIBUTION IN 936 PERSONS WITH SCOLIOSIS

| Age | Mild | Moderate | Severe | Total (*No.*) | Total (*Per cent.*) | Per cent. of 50,000 Persons Whose Minifilms Were Examined | Rate per 1000 |
|---|---|---|---|---|---|---|---|
| 15–19 | 116 | 10 | 8 | 134 | 14.3 | 8.6 | 31.2 |
| 20–29 | 152 | 25 | 19 | 196 | 21.0 | 21.7 | 18.1 |
| 30–39 | 150 | 26 | 16 | 192 | 20.5 | 21.7 | 17.7 |
| 40–49 | 101 | 22 | 20 | 143 | 15.3 | 17.2 | 16.6 |
| 50–59 | 80 | 14 | 11 | 105 | 11.2 | 14.2 | 14.8 |
| 60–69 | 64 | 18 | 11 | 93 | 10.0 | 9.7 | 19.4 |
| 70 plus | 41 | 18 | 14 | 73 | 7.8 | 6.9 | 21.2 |
| Total | 704 | 133 | 99 | 936 | 100.1 | 100.0 | |

fifteen to nineteen years of age than it was in any other age group. The lowest percentage of mild curves was in the group seventy years of age or over (56.2 per cent.).

In the course of the analysis of etiology, 230 cases of scoliosis were found among the first 15,000 films examined (Table V). Approximately two-thirds of these cases appeared to be of a postural or functional type and one-fourth of an idiopathic type. Because of many variables, however, the authors were not certain of many of these diagnoses. These variables included the extent of the spine appearing on the film, the amount of soft-tissue shadow overlying the bone structures (the shadows sometimes made it impossible to identify the structures), and the degree of rotation (rotation sometimes caused erroneous interpretations). The authors were certain of the seven cases diagnosed as congenital scoliosis and of the six cases showing evidences of a thoracoplasty, but the six cases diagnosed as paralytic could very easily have been due to a different cause.

In determining the level of the apex of the curve (Table VI), the authors found that the number of cases with the level between the eighth and tenth thoracic vertebrae (53 per cent.) was larger than the combined number of cases with the level between the fifth and seventh thoracic vertebrae (35 per cent.) and between the eleventh thoracic vertebra and the second lumbar vertebra (12 per cent.). The highest incidence of cases with the

TABLE V

PROBABLE ETIOLOGY IN 230 CASES OF SCOLIOSIS FOUND IN THE EXAMINATION OF THE FIRST 15,000 CHEST ROENTGENOGRAMS

| Etiology * | No. | Per cent. |
|---|---|---|
| Postural | 150 | 65.2 |
| Idiopathic | 61 | 26.5 |
| Congenital | 7 | 3.0 |
| Caused by thoracoplasty | 6 | 2.6 |
| Paralytic | 6 | 2.6 |
| Total | 230 | 99.9 |

Incidence: 15 per 1000 (1.5 per cent.)

* The following criteria were used in determining the etiology:

1. Postural: mild-to-moderate S curves.
2. Idiopathic: S curves with a maximum curvature of 30 degrees or more.
3. Congenital: definite congenital malformations.
4. Caused by thoracoplasty: definite evidence of rib removal.
5. Paralytic: long C curves.

TABLE VI

LEVEL OF APEX AND DIRECTION OF CURVE IN 936 PERSONS WITH SCOLIOSIS

| | Mild (*Per cent.*) | Moderate (*Per cent.*) | Severe (*Per cent.*) | Total (*Per cent.*) |
|---|---|---|---|---|
| *Level of Apex of Curve* | | | | |
| From the fifth to the seventh thoracic vertebrae | 27 | 35 | 42 | 35 |
| From the eighth to the tenth thoracic vertebrae | 64 | 52 | 43 | 53 |
| From the eleventh thoracic vertebra to the second lumbar vertebra | 9 | 13 | 15 | 12 |
| *Direction of Curve* | | | | |
| Left | 25 | 16 | 16 | 19 |
| Right | 75 | 84 | 84 | 81 |

Ratio: Left: Right:: 1: 4 (approximate)

level between the eighth and tenth thoracic vertebrae occurred among subjects with mild curves (64 per cent.).

The convexity of the curve was to the right in 81 per cent. of the cases. The highest incidence of this right curve was in the groups with moderate and severe curves (Table VI). There was no difference between male and female in the incidence of the direction of the curve.

An analysis of the severe curves showed that more than two-thirds of these were under 60 degrees (Table VII). There were eleven cases with excessive curves of above 90 degrees.

## DISCUSSION

In the review of the English and American literature, the authors found little information on scoliosis statistics of the type given in this study. In 1947, Dewar of Toronto reviewed 20,000 minifilms made during a survey for tuberculosis in the Province of Ontario. His study was never completed because, as he states, "it was not dependable". He found an incidence of scoliosis of approximately 4 per cent., an incidence which he felt was much too high and which is slightly more than double the incidence found in the authors' series. He states, "As I went along, I felt that I was interpreting far too many spines as having a scoliosis, when in reality, they were just turned slightly in a right oblique position."

In 1949, Niebauer reviewed 190 minifilms which had been reported as showing scoliosis by roentgenologists. These minifilms were among 75,235 taken during a survey for tuberculosis in persons from the age of one year to over sixty-five years. This study was done in San Mateo County, California. The figures in this study showed an incidence of 2.5 per 1000. In the age group of subjects twenty to sixty-five years old, there was an

TABLE VII

DISTRIBUTION OF NINETY-NINE SEVERE CURVES

| Degrees | Number |
|---|---|
| 30–39 | 30 |
| 40–49 | 28 |
| 50–59 | 12 |
| 60–69 | 7 |
| 70–79 | 5 |
| 80–89 | 6 |
| 90–99 | 8 |
| 100–109 | 3 |
| Total | 99 |

incidence of 4.2 per 1000 (117 cases appeared in 28,209 minifilms). Niebauer states that he did not publish this study for two reasons, (1) because it was his "feeling that perhaps the radiologist in surveying these films for chest diseases may have missed many unusual cases of scoliosis," and (2) because "It was obvious in reviewing the minifilms that in some instances it would be almost impossible to determine if a minimal scoliosis were present because the spine was poorly defined." The incidence of 4.2 per 1000 for the group twenty to sixty-five years of age is comparable to the incidence in our series of five per 1000 for the subjects with moderate and severe curves. It is most likely that the roentgenologists did not report minifilms showing a mild scoliosis.

In some textbooks there are a few references to scoliosis statistics. In their textbook first published in 1929, Jones and Lovett state, "Figures with regard to the frequency with which scoliosis is found in the population as a whole are lacking, except for some figures brought forward by Schanz." In 1910, Schanz stated that of 189,000 army recruits examined in Germany over a five-year period, 7.2 per 1000, or less than 1 per cent., were disqualified for spinal curves of all kinds. Selective Service figures show that of 2,096,551 registrants examined in the United States from July 1, 1950, through December 31, 1951, 2.4 per thousand were disqualified for curvatures of the spine. (These curvatures were not broken down as to lateral or anterior-posterior curves.) This is one-third of the German rate, a variation which is undoubtedly due to the difference between the disqualifying factors for military service in the United States today and those for service in the old German Army. In our series the rate of scoliosis per 1000 was nineteen, but only five per 1000 had the moderate and severe curves which might be considered disqualifying for military service *. This rate represents the mean figure between the German and Selective Service rates.

Whitman states that Drachmann found an incidence of 1.3 per cent. among over 28,000 school children in Denmark. Whitman further states that of 3,252 persons with scoliosis seen at the Hospital for Ruptured and Crippled in New York City during a fifteen-year period, 21.5 per cent. were males and 78.5 per cent. were females. On a yearly basis the percentage of males varied from 14.8 to 25.1. Our figure of 24.3 per cent. for the males is 3 per cent. higher than Whitman's average figure for the males. It is interesting that Jones and Lovett should state, "It is generally the opinion that in adults women show a greater number of scoliotics than men, although published statistics confirming this fact do not exist."

McMurray, writing on scoliosis, says that "in young children the deformity is found to occur in the same proportions in male and female, but later, when adolescence is reached, there is a persistent increase in the percentage of females affected as compared with males, to such an extent that in children requiring treatment the proportions are five females to one male." Our average proportion of three females to one male is definitely lower than the proportion of McMurray's. In our lowest age group (subjects fifteen to nineteen years old) the percentage goes up only slightly, being 3.4 to one.

Steindler writes that the maximum incidence of scoliosis occurs in children between eight and fourteen years of age. Our statistics do not include children under fifteen; according to these statistics, however, the maximum incidence is in children between fifteen and nineteen years of age. Steindler also states that male patients show more left convex curves than right curves, the ratio being sixty-five to thirty-five. Our statistics do not confirm this observation, for in our series 74.6 per cent. of the curves in the males were to the right. In the females 74.5 per cent. of the curves were to the right.

The authors realize that statistical studies of this type are usually not too satisfactory; however, they feel that this statistical study does at least present information which is

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* Non-acceptable for military service (1) "if there is a lateral deviation of the spine from the midline of more than two inches" (Army Regulations, No. 40-115, August 20, 1948) and (2) if the scoliosis has "a deviation of more than two inches from the normal position" (Army Regulations, No. 40-105, January 9, 1952).

not now available in the English literature. The authors are certain that in this study some of the curves were improperly determined, and they are also aware that many errors may have resulted from basing a study of bone pathology on roentgenograms which were made for a study of soft tissue. They have made every attempt to allow for errors, however, and have tried to analyze the material so as to present as clear a picture as possible. The population of the State of Delaware is five eighths urban, two eighths rural non-farm, and one-eighth rural farm and is made up of many different nationalities. It is believed that the population of Delaware is typical of the population found along most of the Eastern Seaboard and that, therefore, these statistics present as accurate a picture as can be obtained of the incidence of scoliosis in any general population of this area.

NOTE: The authors wish to express their appreciation to the Delaware Anti-Tuberculosis Society, and other participating organizations for permission to review the 50,000 minifilms used in this study.

## REFERENCES

1. DEWAR, F. P.: Personal communication.
2. DRACHMANN: Cited in Whitman[9].
3. JONES, ROBERT, and LOVETT, R. W.: Orthopaedic Surgery. Ed. 2, p. 718. London, Oxford University Press, 1929.
4. MCMURRAY, T. P.: A Practice of Orthopaedic Surgery, p. 215. Baltimore, William Wood and Co., 1937.
5. NIEBAUER, J. J.: Personal communication.
6. SELECTIVE SERVICE SYSTEM Official Reports from Standard Form 88 ("Report of Medical Examination"), Washington, D. C., U. S. Government Printing Office, 1950–1951.
7. SCHANZ, A.: Uber Skoliosenbehandlung in der Schule. Verhdl. d. Deutschen Ges. fur. Orth. Chir., **27:** 453–456, 1910.
8. STEINDLER, ARTHUR. Diseases and Deformities of the Spine and Thorax, p. 168. St. Louis, C. V. Mosby Co., 1929.
9. WHITMAN, ROYAL: A Treatise on Orthopaedic Surgery. Ed. 6, pp. 145–146. Philadelphia, Lea and Febiger 1919.

# CANCELLOUS-BONE GRAFTING FOR NON-UNION OF THE TIBIA THROUGH THE POSTEROLATERAL APPROACH *

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Non-union and delayed union are well known complications frequently encountered in diaphyseal fractures of the tibia. In reviewing 395 simple and compound tibial fractures in adults, Albert found an incidence of delayed union of 29 per cent. (twenty weeks was accepted as the "dividing line between 'normal' and 'delayed' or 'slow' union"). In reviewing 417 cases of tibial and fibular fractures, Watson-Jones and Coltart found that only 77.4 per cent. of the fractures had united by the twenty-fourth week. Brumback reviewed 120 cases of tibial fractures and reported that in 21.6 per cent. surgery was required to effect healing; and Stuck and Dunlap reported that of the sixty-eight compound fractures of the tibia and fibula treated by them, twenty resulted in non-union or limited union (secondary bone-grafting operations were performed in twenty-two of the sixty-eight patients). On the basis of these figures, it would appear that slightly less than one of every three fractures of the tibia will present a problem of union.

The causes for slow union and non-union of fractures have been set forth by Watson-Jones and Coltart, while Kolodny and May have been especially concerned with the blood supply of the injured bone. The necessity for resecting the interposing fibrous tissue between the bone ends and for opening the medullary canal has been emphasized by Henderson and Campbell[5,6,7,8,18,19]. Bosworth has extolled the virtues of autogenous-bone grafts over homogenous-bone grafts, and, at one time, rigid internal fixation of massive cortical grafts was considered the best treatment[5,6,7,8,18,19]. Fixation of the graft to the fragments with metal screws, plates, and other devices has vied with fixation by autogenous milled-bone screws, tendons, and gut; no internal fixation except that afforded by the host tissues has also been advocated. Many techniques and modifications of techniques have been described in the literature, and numerous suggestions for dealing with infected bones and draining sinuses have been offered[2,10,12,13,20,27,30,33,34,36].

In 1944, Murray summarized the basic problems involved in bone-grafting. Three years later Phemister demonstrated that cancellous grafts laid alongside the fracture site without disruption of the non-union and without internal fixation may be expected to stimulate the bone to unite. The advantages of cancellous bone over cortical bone, especially in potentially infected areas, are now generally appreciated. Huntington, Codivilla, and Milch have described and recommended synostosing the tibia and fibula to provide stability for the ununited tibia, and the advisability of circumventing the infected area was commented upon by Miller among others. Despite improvements in the techniques of bone-grafting, each ununited fracture of the tibia still presents a challenge. This is especially true if the fracture has been recently infected[11,14,15], for a long delay between the closure of the draining wound and the grafting of the bone is necessary if the incision is to traverse the contaminated area. In 1945, Harmon described the posterolateral approach to the tibia.

The ununited fractures of the tibia described here were treated through the posterolateral approach. In utilizing this approach, the authors followed what they believed to be the best of the principles considered.

1. Synostosing the fibula and tibia above, below, and at the level of the fracture site is a logical means of surgically seeking stability in the presence of a non-union of the tibia.

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* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Los Angeles, California, January 31, 1955.

2. Autogenous cancellous or cortico-cancellous (iliac) bone cut into thin strips or small fragments constitutes the best grafting material.

3. Internal fixation of the graft, except by the host tissues, is not essential and is undesirable in some instances.

4. It is not necessary to resect the bone ends or the fibrous tissue between them in order to obtain stability.

5. The surgical approach for the graft should not enter or pass through an actively or recently infected area.

6. Drainage from the front of the leg may not be a contra-indication to grafting by the above technique if the fibrous barrier across the fracture is left undisturbed.

The operative technique used in the posterolateral approach is as follows. With the patient prone and a tourniquet about the affected extremity, the leg is prepared, draped, and externally rotated. The posterior lateral border of the fibula is palpated opposite the ununited tibia. (Originally the fibula may have been fractured as well as the tibia, but in most instances this fracture will have already united. If an angulatory deformity is present, it may be necessary to osteotomize the fibula well above or below the tibial defect in order to correct this deformity.) A skin incision seven inches long is made just behind and parallel to the posterolateral border of the fibula, with the mid-point of the incision at the level of the tibial defect. The indistinct white line that delineates the insertion of the posterolateral intermuscular septum into the deep fascia is identified. The posterolateral septum, arising from the posterolateral border of the fibula, separates the lateral compartment of the leg from the posterior compartment. The former compartment contains the peronaeus longus and brevis muscles, while the latter contains the gastrocnemius, soleus, flexor hallucis longus, flexor digitorum longus, and tibialis posterior muscles. The latter compartment also contains the posterior tibial and peroneal vessels and nerves which lie upon the superficial surface of the tibialis posterior muscle.

The posterior compartment of the leg is entered, and the posterior surface of the posterolateral septum is followed to the fibula. The gastrocnemius and soleus are retracted posteriorly. The flexor hallucis longus is encountered at the posterolateral border of the fibula. Along this border the periosteum is incised throughout the length of the wound. The long toe flexor is then elevated away from the fibula subperiosteally. Dissection is continued anteriorly and then medially along the posterior surface of the intermuscular septum in order to elevate the tibialis posterior muscle. The posterior tibial and peroneal vessels and nerves that course on the superficial surface of the tibialis posterior muscle are not seen in the operative field.

The periosteum of the tibia is incised along its lateral border where it joins the intermuscular septum, and the flexor digitorum longus is elevated subperiosteally for a distance of two to three inches above and below the site of non-union. Usually, because of scarring at the fracture site, it is easier to traverse the leg above or below the fracture first and then to extend the exposure proximally or distally across the pseudarthrosis. (In our cases, the fibrous tissue between the fragments was left undisturbed, as recommended by Phemister, except in one case in which a cuneiform osteotomy with resection of the pseudarthrosis was done in order to correct an angulatory deformity.) If there has ever been drainage from the front of the leg, care should be exercised not to penetrate the interosseous membrane or the thick fibrous barrier across the back of the fracture site.

When the exposure has been completed, chips and strips of cancellous bone (approximately six ounces by volume) are packed beneath the elevated muscles behind the tibia, across the interosseous membrane, and along the medial surface of the fibula for a distance of two to three inches above and below the fracture. The bone used may be homogenous, autogenous, or both.

The elevated muscles are allowed to fall back against the grafts, and the deep fascia, the subcutaneous tissue, and the skin are loosely approximated. (In the early operations

TABLE I

| | |
|---|---|
| Operations on legs prior to bone-grafting | 65 |
| Drainage from the front of the leg at the time of the posterior bone-grafting | 10 |
| Saucerization anteriorly after closure of the posterior lateral wound (under the same anaesthetic) | 3 |
| Subsequent cessation of drainage and closure of the anterior defect without infection of the graft | 9 |
| Subsequent infection of the graft with continuation of drainage | 1 |

performed by the authors, the tourniquet was removed at this point; later, however, when it became evident that pressure alone could not be depended upon to prevent hematoma formation, the tourniquet was removed prior to implantation of the graft.) A posterior splint is applied in such a way that any swelling or hematoma formation may be accommodated. The wound is inspected at the end of twenty-four hours to determine if spreading of the skin margins seems indicated for evacuation of a hematoma. Two weeks after the operation, when the wound has healed, a circular mold or a lacing leather-cuff type of brace is applied.

Twenty-two ununited tibiae in twenty adults have been treated by this method. Prior to the posterolateral bone-grafting, sixty-five operations had already been performed on the involved extremities (Table I). Drainage from the front of the leg at the time of bone-grafting was present in ten instances. In three of these instances saucerization through a separate anterior incision was performed after closure of the posterolateral wound, under the same anaesthetic. In none of these legs did the bone grafts become infected. Cessation of drainage and closure of the anterior defect without further surgery occurred in nine of the legs, but in the tenth leg drainage continued and subsequently an infection developed in the graft.

Autogenous iliac bone constituted the graft material in fourteen legs. In six legs, homogenous cancellous bone was used, and in two legs, in one patient, a combination of homogenous and autogenous cancellous bone was used.

CASE 1. J. I. H., a white male, forty years old, was admitted to the Veterans Administration Hospital, Little Rock, on January 14, 1951 (Fig. 1-A). On April 4, 1950, this patient had suffered compound fractures of both tibiae and fibulae. Initial treatment consisted in immobilization in plaster, with pins through the tibiae above and below the fracture. The pins were removed after three months, but the tibiae were still not united. On June 28, 1951, the tibiae were exposed anteriorly, and bone taken from the patient's left ilium was laid along the sites of non-union. This procedure was also unsuccessful. On April 23, 1952, bilateral posterior grafting operations were performed, a combination of autogenous iliac bone and homogenous cancellous bone being used. Both wounds healed by first intention. On July 2, 1952, the patient returned from leave with one cast removed and with the other cut off below the knee; toe-to-groin casts were re-applied. By October 10, 1952, full weight-bearing without support was allowed, and roentgenograms made on December 22, 1953, showed that the tibiae had united (Fig. 1-B).

Metal pins, plates, or screws were found in the tibiae of six patients at the time of bone-grafting. In one instance, the screws were removed from the front of the leg after the graft had been inserted; in two others, the metal devices were removed later after osseous healing had been completed; in three cases, the metal was left undisturbed (Table II). In one patient an oblique osteotomy of the healed fibula was performed in order to correct an angulatory deformity. In another (the only patient in whom the fibrous tissue between the bone ends was resected), a cuneiform osteotomy of the tibia was performed, also in order to correct an angulatory deformity.

There were nineteen postoperative complications. These complications occurred in seven of the twenty-two legs, and fifteen of them were regarded as not affecting the end results (Table III). Two patients complained of a mild paraesthesia in the sole of the foot. This condition disappeared within three or four weeks in both cases. Retraction

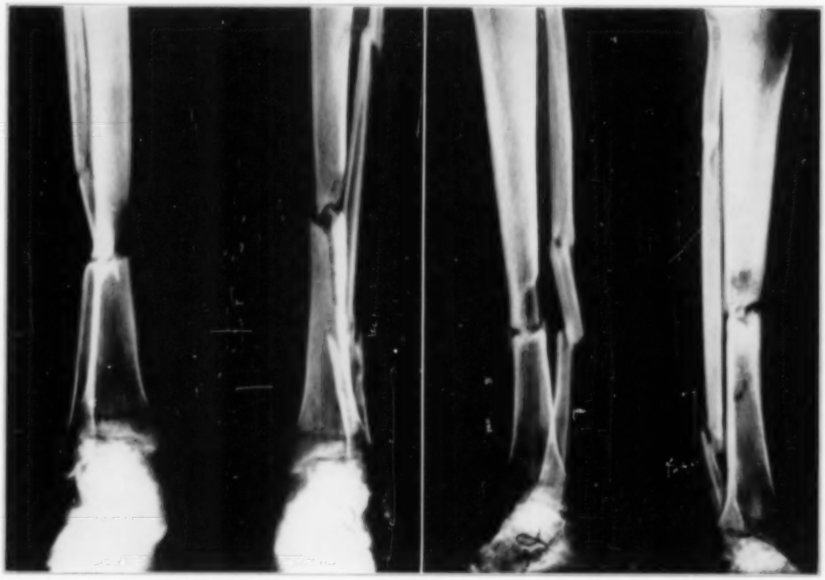

FIG. 1-A

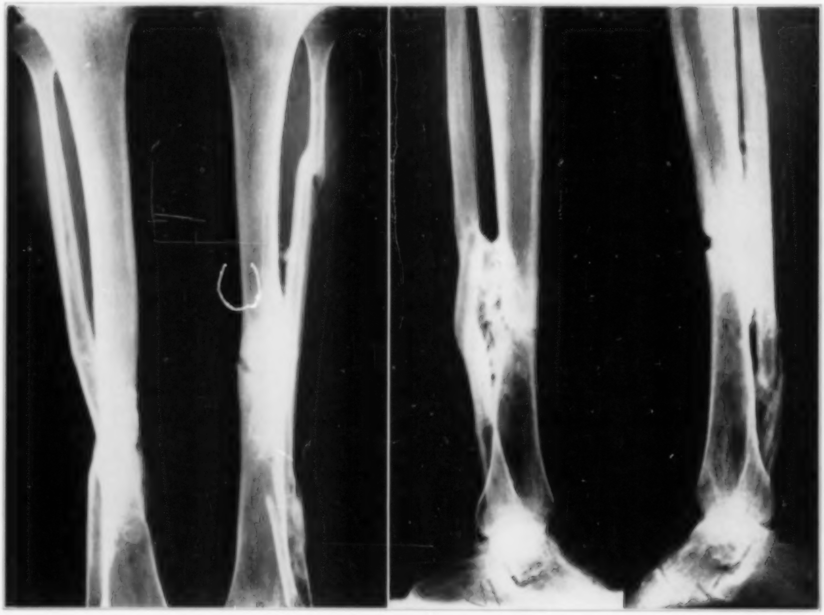

FIG. 1-B

of the muscles and nerves combined with postoperative oedema caused by a massive graft would account for its presence. Significant pain at the operative site was present in four cases; in all these cases the pain was associated with pressure from a circular cast, and for this reason, a posterior plaster mold is now used initially, being replaced by a circular mold or a lacing leather-cuff brace after wound healing is completed. Hematoma was the

TABLE II

| | | |
|---|---|---|
| Metal already in or attached to bone at time of grafting | | 6 |
| Metal removed at time of posterior bone-grafting | | 1 |
| Metal subsequently removed | | 2 |
| Osteotomies | | 2 |
| Fibula | 1 | |
| Tibia and Fibula | 1 | |

most frequent complication, occurring in five legs, all of which were handled satisfactorily by spreading of the wound edges and evacuation of the clot. In one patient, a slough, one by two centimeters, developed in the scar area due to cast pressure over the anterior prominence of the fracture. Healing followed removal of the pressure. Also as a result of cast pressure, skin sloughs developed in three patients along the operative incision. One slough was of sufficient magnitude to warrant a small skin graft; another was closed secondarily; and the third healed without surgery. In none of these patients with skin sloughs did the bone grafts become infected.

There were two graft infections and both of these occurred in patients in whom homogenous bone had been used. In one of these patients, there was minimal drainage from the surgical incision with intermittent sequestration of a few fragments of cancellous bone over a two-month period. Closure of the wound occurred only after a considerable amount of the bone graft had been lost. Eleven months after the operation, the leg was still springy at the fracture site. The tibia in this case had been infected prior to bone-grafting, although drainage had not occurred for several months. The other graft infection occurred in a leg which was draining from the anterior wound at the time the graft was inserted. Four months after the operation, there was still drainage from the leg with obvious extension of the infection into the graft; nevertheless, clinical tests showed that there was no motion at the fracture site.

An anteroposterior angulatory deformity of approximately 10 degrees developed in one patient following unsupported weight-bearing three months after operation. Solid union occurred in this position, and the patient did not desire additional treatment.

TABLE III

POSTOPERATIVE COMPLICATIONS

(Occurring in Seven Legs)

| Complication | | Number |
|---|---|---|
| Minor Complications (15) | | |
| Paraesthesia of sole of foot | | 2 |
| Pain in operative site (associated with a circular cast) | | 4 |
| Hematoma in surgical wound | | 5 |
| Slough of skin over front of leg at site of old scar | | 1 |
| Slough of skin at site of lateral incision | | 3 |
| Skin graft (small) | 1 | |
| Secondary closure | 1 | |
| Healing with dressing only | 1 | |
| Significant Complications (4) | | |
| Infection of graft | | 2 |
| No drainage at time of grafting (the drainage ceased, but non-union is still evident) | 1 | |
| Drainage at time of grafting (the drainage has continued, but the leg is stable) | 1 | |
| Angulation of leg post-graft | | 1 |
| Circulatory impairment in foot (two years postoperative) | | 1 |
| | TOTAL | 19 |

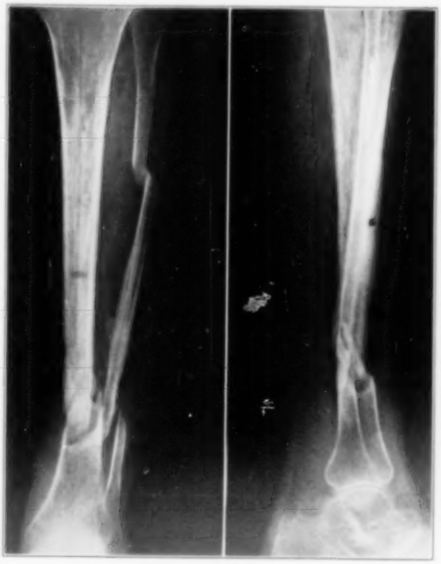

FIG. 2-A

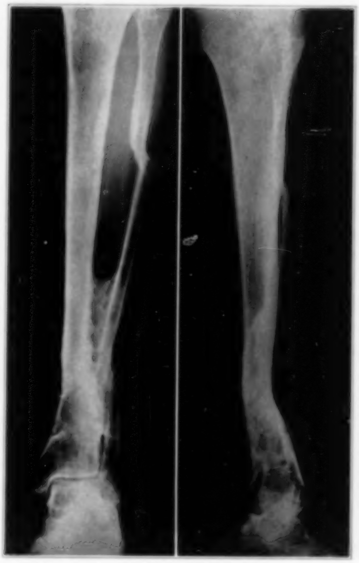

FIG. 2-B

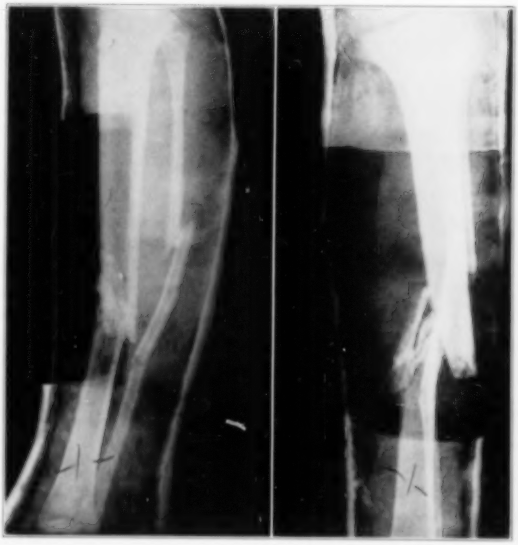

FIG. 3-A

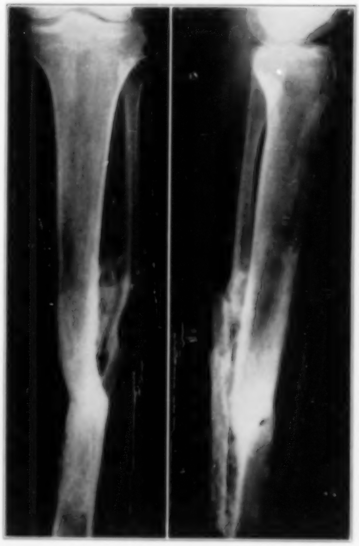

FIG. 3-B

Two years after operation, ulceration of the great toe developed in one patient. A sympathectomy and lengthening of the heel cord were required.

CASE 2. B. F. H., a white male, forty-five years old, was admitted to the Veterans Administration Hospital on June 30, 1951, following an automobile accident. He was unconscious and in shock. The examination revealed bilateral compound comminuted fractures of both tibiae and fibulae in addition to other injuries. The examination also revealed a stiffened left knee joint with a valgus deformity of 10 degrees, a condition which had been caused by an earlier accident. The circulation of the right leg and foot had been destroyed, and a below-the-knee guillotine amputation was performed. Dressings were applied to the left lower extremity, but no attempt was made at this time to reduce the fracture or to close the wounds. By

## TABLE IV

### Results

| Patients | Previous Operative Procedures | Drainage Prior to Graft | Drainage at Time of Graft | Saucerization at Time of Graft | Subsequent Cessation of Drainage | Osteotomy at Time of Graft | Autogenous Graft Cancellous | Homogenous Graft Cancellous | Mixed Autogenous and Homogenous Cancellous Graft | Metal in Bone at Time of Graft | Hematoma, Postoperative (Evacuated) | Breakdown of Skin Postoperative | Skin Slough | Circulatory Impairment Immediately Postoperative | Infection of Graft Closure of Wound | Infection of Graft Continuation of Drainage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. J.—C/M/56 | 2 | × | × | | × | tibia<br>fibula | × | | | | | | | | | |
| J. P.—W/M/71 | 4 | × | × | × | × | | × | | | | | | | | | |
| D. D.—C/M/38 | 4 | × | × | | × | | × | | | | | | | | | |
| M. D.—W/M/29 | 2 | × | × | | × | | × | | | × | × | | × | | | |
| V. T.—C/F/30 | 3 | × | × | | × | | × | | | | × | | | | | |
| W. B.—W/M/25 | 2 | × | × | × | × | | × | | | × | | | | | | |
| J. N.—C/M/55 | * | × | × | × | × | | | × | | | | | | | | |
| B. H.—W/M/42 | 3 | × | × | | × | | × | | | | | | | | | |
| L. S.—W/M/26 | 16 | × | × | | | | | × | | | × | | | | | × |
| M. P.—C/M/41 | 2 | × | × | | × | | | × | | | | | × | | | |
| E. P.—C/M/55 | 2 | | | | | | × | | | × | | | | | | |
| W. W.—W/M/49 L. | 1 | | | | | | × | | | | | | | | | |
| R. | | | | | | | × | | | | | | | | | |
| J. H.—W/M/40 R. | 2 | | | | | | | | × | | | | | | | |
| L. | 2 | | | | | | | | × | | | | | | | |
| C. W.—W/M/41 | 1 | | | | | | | × | | | | | | | | |
| C. H.—W/M/26 | 1 | | | | | fibula | × | | | | | × | × | | | |
| W. E.—W/M/30 | 2 | × | | | | | × | | | | | | | | | |
| A. P.—W/M/17 | 1 | | | † | | | × | | | × | | | | | | |
| C. H.—C/M/34 | 11 | × | | | | | | × | | | × | | | | × | |
| H. T.—W/M/30 | 1 | | | | | | × | | | × | × | | | | | |
| W. M.—W/M/40 | 2 | | | | | | | × | | × | | | | | | |
| Total | 64 | 12 | 10 | 3 | 9 | | 14 | 6 | 2 | 6 | 5 | 1 | 3 | 0 | 1 | 1 |

* Sympathectomy, lumbar — prior to bone graft. ** Removal of screws at time of bone graft.

July 5, 1951, definitive surgery could be begun. Secondary closures of the amputation stump of the right leg and of the wounds of the left leg, along with reduction and immobilization of the fracture by a cast and by Steimann pins, were performed.

The postoperative course was generally satisfactory, although the site of the fracture in the left tibia continued to drain. On December 12, 1951, the wound was debrided, and the local skin flaps were shifted. Following this surgery, the soft tissue healed and the drainage ceased (Fig. 2-A). On April 9, 1952, a posterolateral grafting with bone from the patient's ilium was performed, and a plaster cast was applied. The wound healed by first intention. On September 9, 1952, clinical tests showed no motion at the fracture site, and the plaster was discontinued. A below-the-knee prosthesis was fitted on the right side on November 5, 1952, when full weight-bearing on the prosthesis and on the grafted extremity was begun. Since that time, the left leg has remained solid and drainage has not recurred. In April of 1954, however (Fig. 2-B), the patient was readmitted because of ulceration beneath the left great toe due to a circulatory deficiency and because of a contracted heel cord. This extremity would have been amputated initially had not the other leg already been destroyed. A lumbar sympathectomy, a heel-cord lengthening, and a posterior capsulotomy at the ankle

TABLE IV

RESULTS

| Period of Immobilization | Brace | Development of Secondary Deformity | Length of Follow-Up | Bony Union | Non-Union | Springy at Fracture Site | Secondary Operations |
|---|---|---|---|---|---|---|---|
| 4 Mons. | | | 5 Mons. | × | | | |
| 3 Mons. | | | 7 Mons. | × | | | |
| 4 Mons. | × | | 20 Mons. | | | × | |
| | | | 7 Weeks | | ? | | Secondary skin closure |
| 4 Mons. | | | 10 Mons. | × | | | Panarthrodesis and resection of foreign body in anterior tibial scar |
| 4 Mons. | | | 5 Mons. | × | | | |
| 6 Mons. | | | 8 Mons. | × | | | |
| 6 Mons. | | Ulcer on large toe | 24 Mons. | × | | | Heel-cord lengthening and sympathectomy |
| 3 Mons. | | | 4 Mons. | ** | | | |
| Continuing | | | 3 Mons. | ? | ? | | |
| | | | 10 Mons. | × | | | Removal of intramedullary nail |
| 4 Mons. | | | 8 Mons. | × | | | |
| 3 Mons. | | | 5 Mons. | × | | | |
| 4 Mons. | | | 18 Mons. | × | | | |
| 4 Mons. | | | 18 Mons. | × | | | |
| 3 Mons. | | Angulation | 7 Mons. | × | | | |
| | | | | ? | ? | | Skin graft |
| 3 Mons. | | | 6 Mons. | × | | | |
| 5 Mons. | | | 8 Mons. | × | | | |
| 3 Mons. | × | | 10 Mons. | | | × | Exploration of sinus tract |
| 3 Mons. | | | 6 Mons. | × | | | Plate removed |
| Continuing | | | 4 Mons. | ? | ? | | |
| 19-legs | | | 17-legs | | | | |
| 16 Weeks | 2 | 2 | 9 Mons. | 16 | 4 | 2 | |

† Stable—but drainage from leg continues.

were performed shortly after admission, and since that time the ulcer has healed.

The following secondary procedures were performed on seven legs. In one patient a small skin graft was necessary about the posterolateral incision, and in another a secondary closure of the wound was performed. In the patient who had temporary drainage from the graft wound, closure took place after a limited exploration of the sinus tract. Removal of metal was performed following union in two legs. A lengthening of the heel cord and a sympathectomy were done in one patient, while a panarthrodesis was performed in another. In the latter patient, the anterior wound scar was revised.

CASE 3. V. I. T., a colored female, thirty years old, suffered multiple injuries including a compound comminuted fracture of the left tibia and fibula following an automobile accident on October 7, 1951.

At the time of admission to the Veterans Administration Hospital, January 11, 1952 (Fig. 3-A), there was an area of infected granulation tissue measuring approximately two by three inches over the anterior surface of the leg, midway between the ankle and the knee. Considerable pus was being discharged from this area, and the tibia had been exposed for a distance of approximately one and one-half inches. Roentgenograms revealed a comminuted fracture of the left tibia and fibula.

On January 23, 1953, under a general anaesthetic, an extensive débridement and saucerization of the left tibia was performed and the wound was packed open. It was noted that the anterior tibial tendon had been sectioned near the junction of the tendon and the muscle belly. On February 27, 1952, and again on May 28, 1952, this wound was re-explored and additional infected bone was removed. By August 20, 1952, the drainage from the leg had lessened sufficiently so that it was possible to apply posterolateral autogenous iliac grafts without entering the infected area. A posterior plaster gutter was applied postoperatively, and the wound healed following evacuation of a small hematoma. On December 18, 1953, a foot-drop brace was applied and partial weight-bearing was begun. Both the osteomyelitis and the fracture were healed.

On September 24, 1954 (Fig. 3-B), a panarthrodesis was performed on the left side because of pain and stiffness in the foot and ankle.

To date the average period of postoperative immobilization in seventeen legs has been sixteen weeks, while the average period of follow-up in twenty-one legs has been nine months.

## CONCLUSION

The twenty-two posterolateral bone-grafting operations performed by the author have produced the following results. In fifteen legs the fractures have united without additional bone surgery, as shown by clinical tests and x-ray. Two legs have become stable but springy after one year. The patients in these two cases are without pain and are walking with the assistance of a leather lacer brace. Each seems to be slowly increasing in strength, and one of the two has been working at heavy labor for more than a year; in this patient, a one-inch tibial defect was bridged by the graft. Two patients were lost to follow-up seven weeks after the operation, at which time they were still in casts but union was progressing satisfactorily. Two patients were still in casts (three and four months after the operation) and union was progressing satisfactorily. The one patient whose wound was grossly infected was last seen four months after the operation, at which time, in spite of the infection, motion at the fracture site was not demonstrable clinically.

In general, grafting through the posterolateral approach is considered very helpful in patients in whom infection of the tibia is already present or in whom it is likely to occur. At times this operation even appears mandatory on economic grounds.

## REFERENCES

1. ALBERT, M.: Delayed Union in Fractures of the Tibia and Fibula. J. Bone and Joint Surg., **26:** 566–578, July 1944.
2. BLAIR, H. C.: A Diamond-Shaped Graft from the Ilium for Non-Union of the Tibia. J. Bone and Joint Surg., **33-A:** 362–370, Apr. 1951.
3. BOSWORTH, D. M.; WRIGHT, H. A.; FIELDING, J. W.; and GOODRICH, E. R.: A Study in the Use of Bank Bone for Spine Fusion in Tuberculosis. J. Bone and Joint Surg., **35-A:** 329–332, Apr. 1953.
4. BRUMBACK, J. E., JR.: Mean Disposition of Tibial Shaft Fractures. Am. J. Surg., **71:** 532–533, 1946.
5. CAMPBELL, W. C.: The Treatment of Ununited Fractures. Am. J. Surg., **37:** 1–3, 1923.
6. CAMPBELL, W. C.: Ununited Fractures. Arch. Surg., **8:** 782–790, 1924.
7. CAMPBELL, W. C.: The Onlay Graft in the Treatment of Ununited Fractures of the Long Bones. Southern Med. J., **20:** 107–114, 1927.
8. CAMPBELL, W. C.: Operative Orthopedics, pp. 716–723. St. Louis, The C. V. Mosby Co., 1939.
9. CODIVILLA, A.: On the Cure of the Congenital Pseudoarthrosis of the Tibia by Means of Periosteal Transplantation. Am. J. Orthop. Surg., **4:** 163–169, Oct. 1906.
10. DAVIS, A. G.: Fibular Substitution for Tibial Defects. J. Bone and Joint Surg., **26:** 229–237, Apr. 1944.
11. FARROW, R. C.: Summary of Results of Bone-Grafting for War Injuries. J. Bone and Joint Surg., **30-A:** 31–39, Jan. 1948.
12. FLANAGAN, J. J., and BUREM, H. S.: Reconstruction of Defects of the Tibia and Femur with Apposing Massive Grafts from the Affected Bone. J. Bone and Joint Surg., **29:** 587–597, July 1947.
13. FLINN, I. M., JR.: Osteoperiosteal Ribbon Grafts in Undisplaced, Ununited Fractures of the Tibia. J. Bone and Joint Surg., **33-A:** 650–658, July 1951.
14. FUNSTEN, R. V., and LEE, R. W.: Healing Time in Fractures of the Shafts of the Tibia and Femur. J. Bone and Joint Surg., **27:** 395–400, July 1945.
15. GOREN, M. L.: Analysis of Fractures of the Shaft of the Tibia in an Army General Hospital. Ann. Western Med. and Surg., **1:** 62–66, 1947.

16. Harkins, H. N., and Phemister, D. B.: Simplified Technique of Onlay Grafts. For All Ununited Fractures in Acceptable Position. J. Am. Med. Assn., **109:** 1501–1506, 1937.
17. Harmon, P. H.: A Simplified Surgical Approach to the Posterior Tibia for Bone-Grafting and Fibular Transference. J. Bone and Joint Surg., **27:** 496–498, July 1945.
18. Henderson, M. S.: Massive Bone Graft Applied for Non-Union of the Humerus. Surg., Gynec., and Obstet., **46:** 397–402, 1928.
19. Henderson, M. S.: The Massive Bone Graft in Ununited Fractures. J. Am. Med. Assn., **107:** 1104–1107, 1936.
20. Henry, R. T.: Fractures of the Shaft of the Tibia. Types and Treatment (Bone Grafts and Non-Union). Rhode Island Med. J., **31:** 299–301, 1948.
21. Huntington, T. W.: Case of Bone Transference. Use of a Segment of Fibula to Supply a Defect in the Tibia. Ann. Surg., **41:** 249–251, 1905.
22. Kolodny, Anatole: The Periosteal Blood Supply and Healing of Fractures. Experimental Study. J. Bone and Joint Surg., **5:** 698–711, Oct. 1923.
23. May, Hans: Double Fractures and Double Non-Unions of the Shaft of the Tibia. Am. J. Surg., **75:** 796–801, 1948.
24. Milch, Henry: Synostosis Operation for Persistent Non-Union of the Tibia. A Case Report. J. Bone and Joint Surg., **21:** 409–413, Apr. 1939.
25. Milch, Henry: Tibiofibular Synostosis for Non-Union of the Tibia. Surgery, **27:** 770–779, 1950.
26. Miller, D. S., and Markin, Leo: Simple Method of Bone Grafting for Nonunion of the Tibia. Arch. Surg., **62:** 548–556, 1951.
27. Moore, J. R.: Delayed Autogenous Bone Graft in the Treatment of Congenital Pseudarthrosis. J. Bone and Joint Surg., **31-A:** 23–39, Jan. 1949.
28. Murray, C. R.: The Basic Problems in Bone-Grafting for Ununited Compound Fractures. J. Bone and Joint Surg., **26:** 437–442, July 1944.
29. Murray, C. R.: The Principles Underlying All Bone Grafting Procedure. *In* Lectures on Reconstructive Surgery of the Extremities, Instructional Course Lectures, The American Academy of Orthopaedic Surgeons, 1944, pp. 532–534. Ann Arbor, J. W. Edwards, 1944.
30. Myerding, H. W., and Cherry, J. H.: Tibial Defects with Nonunion Treated by Transference of the Fibula and Tibiofibular Fusion. Am. J. Surg., **52:** 397–404, 1941.
31. Phemister, D. B.: Treatment of Ununited Fractures by Onlay Bone Grafts Without Screw or Tie Fixation and Without Breaking Down of the Fibrous Union. J. Bone and Joint Surg., **29:** 946–960, Oct. 1947.
32. Stuck, W. G., and Dunlap, Knox: End Results of Treatment of Compound Fractures of the Tibia. Mil. Surg., **105:** 282–286, 1949.
33. Wagner, J. H.: Anterolateral Approach in Bone Grafting for Ununited Fractures of Tibia. Am. J. Surg., **73:** 282–299, 1947.
34. Wallace, Paul: Treatment of Fractures with Long Standing Osteomyelitis. Results of Use of the Tibial Sliding Graft. Arch. Surg., **61:** 379–386, 1950.
35. Watson-Jones, R., and Coltart, W. D.: Slow Union of Fractures. With a Study of 804 Fractures of the Shafts of the Tibia and Femur. British J. Surg., **30:** 260–275, 1942.
36. Wilson, P. D.: A Simple Method of Two-Stage Transplantation of the Fibula for Use in Cases of Complicated and Congenital Pseudarthrosis of the Tibia. J. Bone and Joint Surg., **23:** 639–675, July 1941.

## DISCUSSION

Dr. Robert Mazet, Jr., Los Angeles, California: Should tibial-shaft fracture fragments be united in twenty or twenty-four weeks? The answer is probably no. A year ago Dr. Marshall Urist [b] reported to this Academy an analysis of one hundred and eighty-five tibial-shaft fractures treated on our service. Among other facts, the following emerged: (1) Patience and prolonged plaster immobilization resulted in a high percentage of union. (2) The healing time was between nine and twelve months if there was a gap of about 0.5 centimeter between the fragments. If a larger gap existed or if infection occurred, the healing time was proportionately prolonged. (3) The cases in this series were put in the non-union group when the surgeon arbitrarily decided to call them such.

In two of the authors' cases grafts were inserted less than a year after the fractures had occurred. These fractures might well have healed without surgery; the preoperation film in one case showed that there had already been some healing of the fracture.

There are instances of non-union which *demand* bone-graft surgery, however. In patients with bad scars, in whom latent infection lingers, an incision through an unscarred area is undoubtedly the best approach. At Wadsworth General Hospital we usually approach the site of non-union either through a posteromedial or through a direct lateral incision. Fixation of the graft by metal is usually not necessary, nor is it essential to excise the fibrocartilaginous callus. Insertion of an autogenous or homogenous bone graft across the fracture site serves as a catalyst and promotes osteogenesis at the fragment ends. The added insult of the operation stimulates repair at these ends.

Dr. Jones mentions tibiofibular synostosis. Using the fibula as a strut, when there is a considerable defect in the tibia, is sometimes very helpful. When the synostosis is done at a distance from the fracture, however, it is inadequate for two reasons. It fails to immobilize the fracture, and it does not stimulate osteogenesis at the fragment ends. Dr. Paul McMaster[a], of our staff, has been using a variation of this operation which we think is better. He introduces two or more peg grafts through the fibula into the tibia above and below but *near* or through the fracture and uses the direct lateral approach. Considerable stability is thus achieved. This method differs from the one just presented in that the fibula is relied on for stability and in that no bone is placed across the fracture site. It is perhaps more applicable when a large gap exists.

Recently one of Dr. Jones' patients came to our hospital. The graft in this patient was inserted April 1952, and thirty months later he could walk on this leg without support. Recent roentgenograms show that the fractures in both bones have healed and that there is a solid cross union extending well above and below the fracture.

The plan of treatment of Dr. Jones and Dr. Barnett meets the criteria of Dr. Key and Dr. Phemister for the operative correction of non-union of the tibia when no large gap exists: (1) it provides the added insult necessary to stimulate latent callus formation, (2) it does not disturb the local blood supply or the fibrocartilaginous callus, (3) in many cases it will prevent relighting of the old infection, (4) it is relatively atraumatic, and (5) it results in an extremity which can bear weight.

This method represents a significant advance in orthopaedic surgery, but is not a universal answer. It is probably most applicable in cases in which there has been infection and scarring and in which there is not a significant gap between the fragments. One must eschew condemning patients with tibial-shaft fractures to surgery until *prolonged* immobilization has failed to result in healing.

a. McMaster, P. E.: Cross Bone-Grafting between the Fibula and the Tibia for Tibial-Bone Defects [*Abstract*]. J. Bone and Joint Surg., **36-A:** 172, Jan. 1954.

b. Urist, M. R.; Mazet, Robert, Jr.; and McLean, F. C.: The Pathogenesis and Treatment of Delayed Union and Non-Union. A Survey of Eighty-Five Ununited Fractures of the Shaft of the Tibia and One Hundred Control Cases with Similar Injuries. J. Bone and Joint Surg., **36-A:** 931-968, Oct. 1954.

Dr. George G. Fox, Meriden, Connecticut: Dr. Jones and Dr. Barnett have described a new approach to an old orthopaedic problem, infected ununited fractures of the tibia. The authors have demonstrated clearly and well that the posterolateral approach is suited ideally to the care of such fractures. This approach also appears to offer a way to treat a badly scarred leg.

In the past, obtaining union has been subordinated to the treatment of the infection, and as a result, sometimes years of hospitalization have been necessary. Now we have been presented with a method for obtaining union even while infection is present. The authors' success in obtaining union and eliminating the infection in such a large percentage of patients with actively draining wounds is remarkable.

Dr. Jones and Dr. Barnett did not specify whether they employed this technique in any patients with non-union in whom there was neither infection nor damage to the anterior soft parts. The standard anterior approach would seem to be much the wiser choice in such cases.

The technique of the posterolateral approach is demanding although not too difficult for the trained surgeon. The authors have emphasized carefully the hazards of the operation as well as the problems of early after-care. The complications that occurred in their cases were not excessive.

Perhaps it is significant that the most troublesome sequelae (vascular impairment and heel-cord contracture) occurred in the patient (Case 4) whose fracture was in the lower third of the tibial shaft. At this level the potential space for bone grafts is far less than it is in the upper portions of the leg. Likewise, the neurovascular bundles are not as well protected by muscle.

Although I have had no personal experience with this technique, I feel that it has great merit in carefully selected cases, and I certainly intend to try it should the opportunity arise.

Dr. Jones (closing): The authors purposely avoided the question of what constitutes non-union. In all their cases, except one, the period between the occurrence of the fracture and the performance of the grafting operation was over six months and the average period was 18.5 months.

The best indication that this operation is necessary would seem to be whether or not the ununited tibia is or has been infected. There seems to be no reason, however, why it cannot be used in cases of tibial non-union in general. Apparently there is little danger of a neurovascular disturbance as the result of placing a graft between the tibia and fibula posteriorly.

The procedure should prove efficacious in bridging most large bone defects. Two of our patients with large defects returned to work, each wearing a lacing leather cuff brace, even though their legs remained springy at the fracture site for many weeks. The defect in one of these patients was one inch in length.

The authors feel this is an operative procedure that deserves a more universal application.

# VERTEBRA PLANA AND THE HISTIOCYTOSES

## Report of a Case with Involvement of Five Vertebrae

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*From the Crippled Children's Hospital, Medical College of Alabama, Birmingham*

In January 1954, at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Compere, Johnson, and Coventry advanced the concept that so-called Calvé's disease is due to eosinophilic granuloma of the vertebral body. They presented four cases with characteristic vertebral changes, in each of which the diagnosis of eosinophilic granuloma had been proved by biopsy. In support of that concept the following case is presented.

### CASE REPORT

M. A., a three-year-old Negro male, was first seen at the Crippled Children's Clinic on October 15, 1952, complaining of pain in the cervical region of six weeks' duration. The mother stated that the child had had no known injury, and had not been particularly ill, but that he held the neck stiffly and resisted any effort to straighten it.

On examination the child was found to have considerable cervical-muscle spasm, but he held the head in the erect position, resisting flexion and extension movements. Roentgenograms made of the cervical region revealed "fusion of the first three cervical

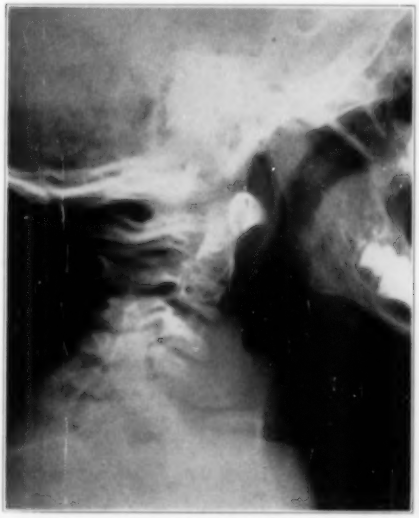

Fig. 1

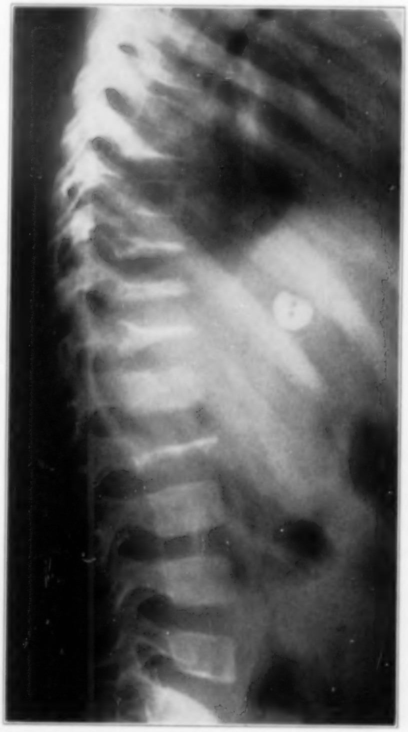

Fig. 2

Fig. 1: Lateral roentgenogram of the cervical portion of the spine, made on October 15, 1952, showing fusion of the bodies of the first two and possibly of the first three cervical vertebrae, with abnormal formation of the remainder of the visible cervical segments.

Fig. 2: Lateral roentgenogram of the thoracic and lumbar portions of the spine, made at admission in February 1953. There was collapse of the bodies of the eighth, tenth, eleventh, and twelfth thoracic vertebrae and of the second lumbar vertebra.

bodies and congenital deformities of the remainder of the cervical segments" (Fig. 1). Admission to the Crippled Children's Hospital was advised, and the mother promised to bring the child the next day, but he was not seen again until February 3, 1953, when he was referred with what was suspected to be poliomyelitis because of a limp. Examination revealed a limp of the left lower extremity with some painful limitation of hip motion on the left. There was also said to be limited motion of the back. Roentgenograms made on the same day showed collapse of the eighth, tenth, eleventh, and twelfth thoracic vertebrae and the second lumbar vertebra (Fig. 2). There was a three-centimeter area of destruction in the inferior ramus of the right ischium and in the region of the ischial tuberosity with additional areas of destruction in the necks and intertrochanteric regions of both femora (Fig. 3). Roentgenograms of the skull, of both tibiae and femora, and of the long bones of the upper extremities revealed no pathological changes.

The patient was admitted to the Crippled Children's Hospital, where further questioning revealed that the previous complaints in the cervical region had subsided in a short while without apparent sequelae. His mother felt that he had been less active, however, since that illness, and mentioned that his appetite had been quite poor. For the two or three weeks before admission, he had complained of pain in the left knee region and had begun limping. He walked alone only when holding on to furniture or other support.

*Laboratory Findings at Admission*

| | | |
|---|---|---|
| Hemoglobin | 50 per cent. | |
| Red blood cells | 3,000,000 per cubic millimeter | |
| Color index | 0.8 | |
| White blood cells | 8,900 per cubic millimeter | |
| Neutrophils | 60 per cent. | |
| Lymphocytes | 29 per cent. | |
| Eosinophils | 3 per cent. | |
| Basophil | 1 per cent. | |
| Immature cells | 7 per cent. | |
| Corrected sedimentation rate | (Wintrobe method) | 13 millimeters per hour |
| There was no sickling of red cells. | | |
| Blood chemistry: | | |
| Calcium | 10.7 milligrams per 100 cubic centimeters | |
| Phosphorus | 4.3 milligrams per 100 cubic centimeters | |
| Alkaline phosphatase | 6.4 Bodansky units | |
| The Kahn test was negative. | The urinalysis was negative. | |
| The tuberculin skin test was negative. | | |

On February 20, 1953, a biopsy of the area of destruction in the left femur was done. The material was described as being grossly firm and granular, with an irregular gray to reddish-brown color. Microscopic examination revealed "a granulomatous lesion made up largely of histiocytes forming granuloma-like nodules. In some areas, these histiocytes are fused into giant cells. There is a very interesting background of eosinophils throughout the tissue, and there is also some increased fibrosis. Foam cells are rare. The picture is typical of the cholesterol histiocytoses. It shows features of Letterer-Siwe's disease, eosinophilic granuloma, as well as Schüller-Christian disease. This is entirely in conformity with the concept of these all being variants of the same process."

After biopsy had been performed, a course of radiation therapy was given to the affected areas. On March 24, 1953, swelling was noted about the left mandible and roentgenograms revealed bone destruction at the mandibular angle. On April 28, 1953, roentgenograms of the skull revealed a one-centimeter area of destruction in the roof of the right orbit. On June 8, 1953, a small osteolytic area was noted in roentgenograms of the proximal end of the right humerus and on August 15, 1953, extensive destruction of the posterolateral portion of the tenth right rib, with a pathological fracture, was seen.

The patient received roentgenotherapy directed to these various areas under the supervision of the roentgenological consultant. The boy was discharged on September 5, 1953, wearing a long corset, after roentgenograms had revealed considerable regeneration of the areas in the pelvis and hips and recalcification of the affected vertebrae.

This child has been regularly followed in the Crippled Children's Clinic and when last seen in September 1954, he was asymptomatic. Physical examination was completely negative, and the mother stated that the child lived a full, active life. Roentgenograms made at the last visit are shown in Figures 4, 5, and 6.

## COMMENT

It is now generally accepted that eosinophilic granuloma, Letterer-Siwe disease, and Schüller-Christian disease constitute different clinical expressions of the same basic disorder. Generally seen in children from five to twelve years of age, eosinophilic granuloma is the least malignant manifestation of this group.

The lack or paucity of signs or symptoms, the absence of changes in the blood chemistry, and the tendency to recover regardless of the type of treatment given are

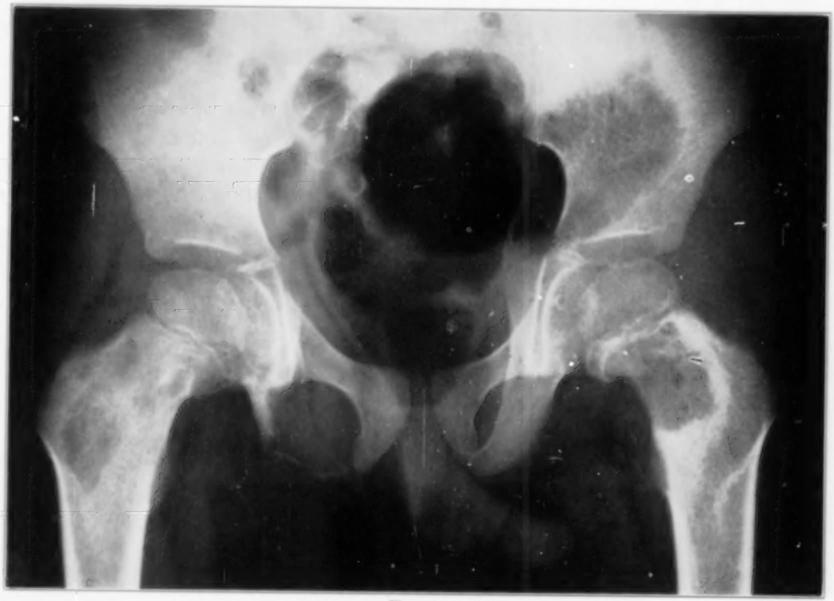

Fig. 3

Roentgenogram of pelvis and upper portions of the femora, showing destruction in the necks and intertrochanteric regions of both femora, as well as of the entire descending ramus and ischial tuberosity on the right.

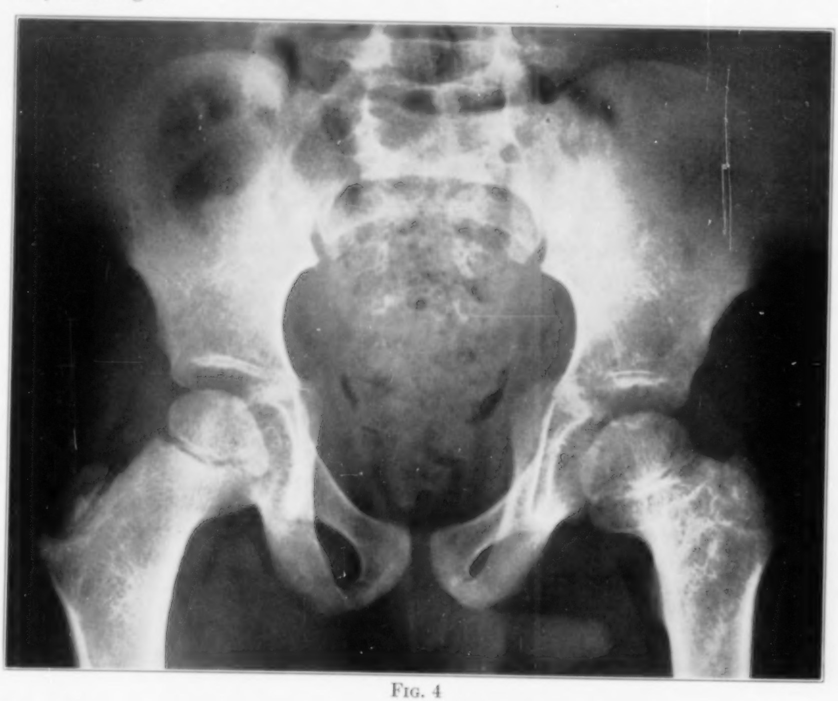

Fig. 4

features of both Calvé's disease and eosinophilic granuloma. Whether fusion of the cervical vertebrae in this case represents a part of the process is not known, but it is known that, in these three forms of reticulosis, lesions may completely erode the cortex of the involved bone. It is also known that the cervical vertebrae differ from the other vertebrae in that the superior surfaces of the bodies of the cervical vertebrae turn upward at each side to form lateral projections and the inferior surfaces of the bodies are beveled laterally to fit the upward lateral projection of the superior surface of the adjacent vertebra. Intervertebral-disc material does not extend to the lateral sides of the vertebrae in the cervical region.[4] Spontaneous fusion occurring as a part of the healing process of an eroded vertebra, then, does not seem improbable. That involvement of the posterior arch can occur in this disease is shown by a case illustrated by Casagrande and Frost, in which the fourth lumbar vertebra was involved.

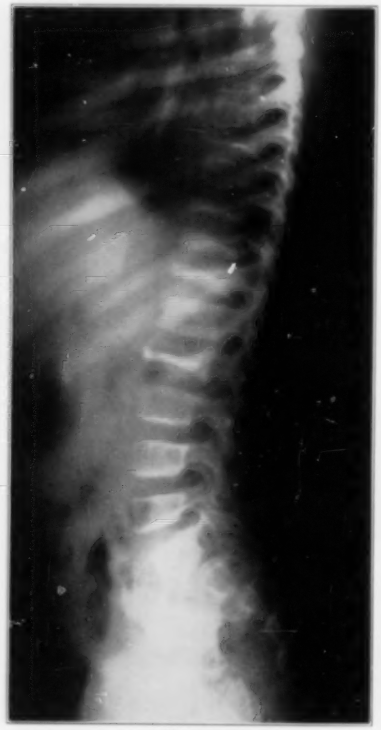

Fig. 5

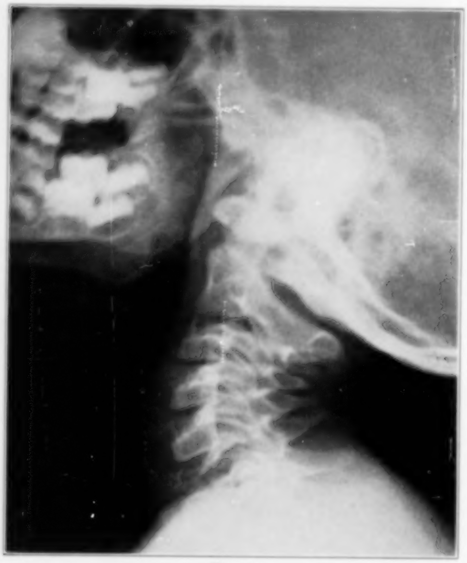

Fig. 6

Figs. 4, 5, and 6: Roentgenograms made on September 7, 1954, showing an anteroposterior view of the pelvis and upper portions of the femora, a lateral view of the lumbar and thoracic portions of the spine, and a lateral view of the cervical portion of the spine. Varying degrees of regeneration are seen in the spine, in the pelvis, and in the femora. The patient has no deformity and is asymptomatic.

Fawcitt in 1940 presented a typical case of Calvé's disease with multiple pathological changes in other bones, including spontaneous fusion of two of the cervical vertebrae, not seen in roentgenograms made seven months previously. Although no biopsy was done, his report of the case in a four-year-old female is much like the case described in this paper, with typical changes of Calvé's disease in two vertebrae. In addition, in Fawcitt's case there were cystic changes in the head and neck of one femur, in the upper shaft of one humerus, and in the pelvis; these were of a transitory nature, with a tendency toward healing.

## REFERENCES

1. Casagrande, P. A., and Frost, H. M., Jr.: Fundamentals of Clinical Orthopedics, p. 244. New York Grune and Stratton, 1953.

2. Compere, E. L.; Johnson, W. E.; and Coventry, M. B.: Vertebra Plana (Calvé's Disease) Due to Eosinophilic Granuloma. J. Bone and Joint Surg., **36-A**: 969–980, Oct. 1954.
3. Fawcitt, Richard: Osteochondritis Vertebralis (Calvé) Associated with Pathological Changes in Other Bones. British J. Radiol., **13**: 172–178, 1940.
4. Jackson, Ruth: The Cervical Syndrome. *In* Instructional Course Lectures, The American Academy of Orthopaedic Surgeons. Vol. X, pp. 65–90, 1953. Ann Arbor, J. W. Edwards, 1953.

## ORTHOPAEDIC RESEARCH AND EDUCATION FOUNDATION

The first meeting of the Board of Trustees of the Orthopaedic Research and Education Foundation was held on October 2, with all formal documents being completed at this time by the lawyer, Mr. J. J. Laughlin, of Cleveland. The Foundation has received checks for $5,000 each from The Association and The Academy and a check for $1,000 from the Association of Bone and Joint Surgery. It was decided at this meeting to have a Founder Member Group of the Foundation and these three organizations were elected the first founder members. This membership is to be for individuals, corporations and institutions, and organizations which through contributions to or unusual interest in orthopaedic research and education, desire to help the work of the Foundation. On November 1, there will be sent out to all orthopaedic surgeons a questionnaire on their desires to carry on orthopaedic research. Following the receipt of the questionnaires, it is hoped that an estimate can be obtained of the amount of money needed at this time. No general solicitation of funds will start until the information on the returned questionnaires has been analyzed and it is not likely anything will be done until after the next meeting of the Foundation Board in Chicago at the time of The Academy meeting. The following are the officers and trustees:

Fig. 1

Dr. Walter P. Blount, President of The American Academy of Orthopaedic Surgeons, presented a check for $5,000 to Dr. A. R. Shands, Jr., President of the Orthopaedic Research and Education Foundation. Dr. T. Campbell Thompson, Medical Director of the Hospital for Special Surgery and immediate Past President of The American Academy of Orthopaedic Surgeons, looks on. Presentation was made at the dedication of the New Hospital for Special Surgery in New York City on September 30, 1955.

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*Vice-President:* Joseph S. Barr, M.D., Boston, Massachusetts;

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The main office of the Orthopaedic Research and Education Foundation is in the Central Office of The American Academy of Orthopaedic Surgeons, 116 South Michigan Avenue, Chicago 3, Illinois.

# RECURRENT DISLOCATION OF THE HIP

BY C. ROGER SULLIVAN, M.D., ROCHESTER, MINNESOTA,
*Section of Orthopaedic Surgery, Mayo Clinic and Mayo Foundation,*
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*Section of Orthopaedic Surgery, Mayo Clinic and Mayo Foundation,*
AND PAUL R. LIPSCOMB, M.D., ROCHESTER, MINNESOTA,
*Section of Orthopaedic Surgery, Mayo Clinic and Mayo Foundation* *

The shoulder has a wide range of movement and is an unstable joint. It is easily dislocated and is frequently subject to recurrent dislocation. The hip, on the other hand, has less motion and more stability. Dislocation occurs only after violent injury, and recurrent dislocation unassociated with acetabular fracture, congenital dysplasia, sepsis, or paralysis is almost unknown.

Nonetheless, a case of recurrent dislocation of the hip was reported by Sir Astley Cooper in the first half of the nineteenth century. In his *Treatise on Dislocations and Fractures of the Joints,* under the category "Dislocation from Relaxation", he described the following case, a case which was reported to him by another surgeon.

> "John Broadhurst, aet. fifty, rather of spare habit, has the power of dislocating and reducing either hip-joint at will. The way in which he effects it is by turning the limb considerably inwards, and bending the knee slightly, when the head of the femur immediately with a crack slips out in the direction backwards, and a little upwards, the neck resting upon the edge of the acetabulum, and by reversing the position of the limb the bone returns into its natural position, leaving only a little aching for a day or two. . . . The luxation is obvious across the room. The period when the dislocation first occurred he cannot precisely remember, nor that any particular accident occasioned its first occurrence, but believes it to be six or eight and twenty years ago, and that a simple change of position first produced it, when it was rectified without surgical aid. The man is a common laborer in a saw-mill, but is subject to asthma, and he has also a hernia, showing a degree of relaxation in his system. It is worthy of remark that he can turn his toes in, and place his feet parallel, and also cross his legs and put his toe behind his heel. In either of these positions dislocation does not occur. Perhaps an hereditary laxity may be remarked, his brother being able to luxate any joint of his fingers at will. This man has not the power of dislocation in any other direction than what I have described."

Heully saw a patient with a similar condition, and Bigelow described three patients, all men, who had unilateral dislocations. Hamilton collected three cases (again, the patients were all men), but the condition in one should not be considered true recurrent dislocation, since there was muscle-wasting and resorption of the femoral head and neck. Ombrédanne reported a case in which a girl, thirteen years old, was able to dislocate the hip at will. In this girl, however, there was some question of congenital aplasia of the posterior part of the acetabulum, and this case also should be excluded from a collection of cases of true recurrent dislocations.

So far as we have been able to determine, the foregoing are the only recorded instances of recurrent dislocation of the hip. Our purpose is to describe the condition of a patient seen by us who had a similar derangement.

## REPORT OF A CASE

A male dishwasher, sixty years old, was first examined at the Mayo Clinic on December 24, 1945. He had registered at this time for examination after amputation through the lower part of the right thigh on July 26, 1944. He said that the right heel had been crushed in a railroad accident thirty-four years prior to the amputation and that this wound had been repaired by means of a skin graft. A squamous-cell carcinoma had appeared over the heel in the grafted area following a fall four months before the amputation. Dissections of lymph nodes of the right groin had been done before and after the amputation, but nodes containing metastatic carcinoma had been found only at the second operation. After amputation roentgen irradiation had been directed to the right inguinal area, and the operative wound had healed slowly, leaving a thick scar. His

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* The Mayo Foundation is a part of the Graduate School of the University of Minnesota.

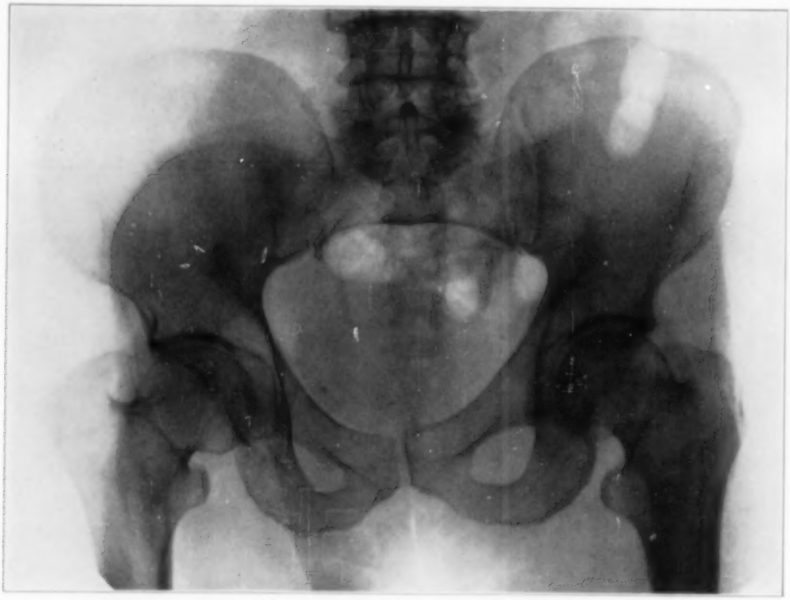

FIG. 1

The hip joints of the patient, as seen on December 24, 1945, were normal.

general health since that time had been excellent.

The patient also said that the right hip had been dislocated in 1937, and that this dislocation had been caused by a simple fall while he was walking on the street. He thought reduction had been accomplished without anaesthesia, but it should be mentioned that on occasions he indulged in strong drink, so that his memory for the exact details of his various injuries was imperfect. Postreduction care had consisted in rest in bed for three weeks, and it is doubtful that he had used crutches. There had been no symptoms referable to the right hip since that time.

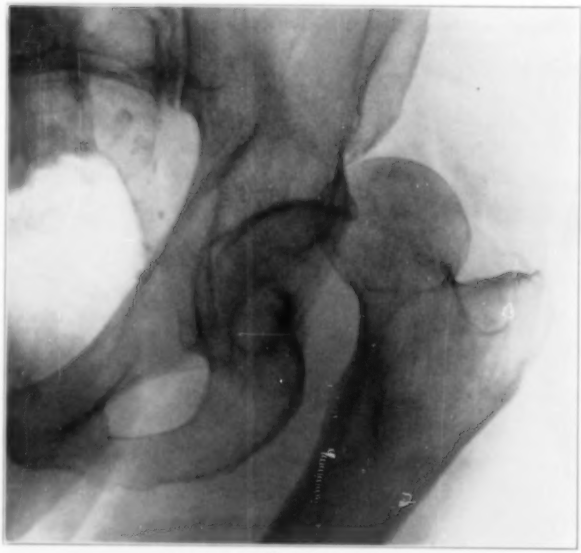

FIG. 2

Recurrent dislocation of the left hip, as seen on August 8, 1954. This roentgenogram is typical of the appearance of the hip in each of the episodes of dislocation.

The results of a general examination, an examination which included a roentgenogram of the thorax, a flocculation test for syphilis, and routine blood counts and urinalysis, were all within normal limits. There was no evidence of recurrent carcinoma. Bilateral nerve deafness was noted. The patient was of an asthenic body type, and he walked well with the aid of an artificial limb attached by pelvic and shoulder straps. There was a small left inguinal hernia, but otherwise the musculoskeletal examination revealed nothing unusual. A roentgenogram of the pelvis (Fig. 1) showed normal hip joints.

The patient was not seen again until January 12, 1947, when he was brought to the Emergency Room after he had fallen on an icy street. The diagnosis was posterior dislocation of the left hip, and the limb was

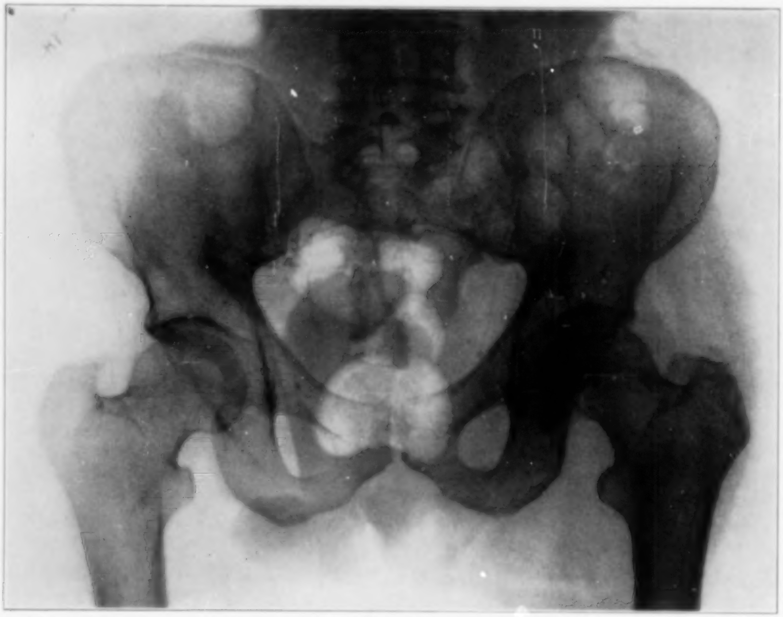

FIG. 3

Roentgenogram made on November 8, 1954. It shows the sequelae of six episodes of dislocation of the left hip. There were minimal hypertrophic changes, but there was no evidence of aseptic necrosis of the femoral head. A small area of myositis ossificans was seen in the abductor muscles.

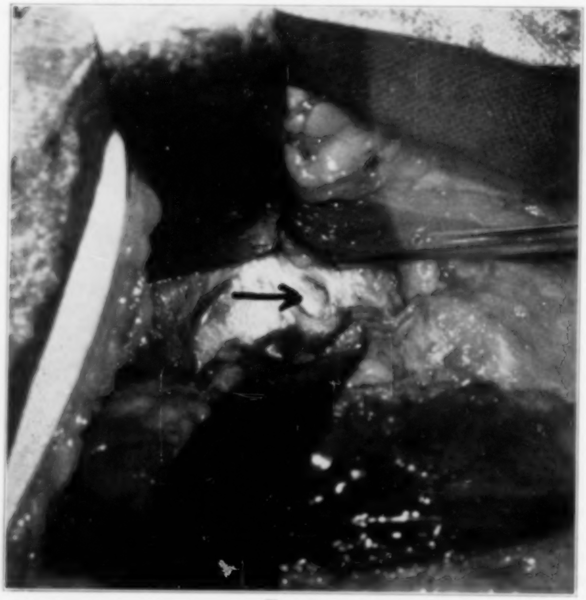

FIG. 4

Photograph made on November 11, 1954, at operation, showing a tear in the superior portion of the capsule.

held in a position of flexion, adduction, and internal rotation. The femoral head was palpable in the buttock. With the patient under spinal anaesthesia, reduction was easily achieved. The patient remained in bed for two weeks with the limb held in Buck's extension and was then allowed to walk with crutches. Even with crutches, he was unable to avoid some weight-bearing on the affected extremity because of the amputation on the right.

The patient did not keep his follow-up appointments, and he was not seen until July 1, 1950. On that date he was again brought to the Emergency Room with a recurrent posterior dislocation of the left hip (Fig. 2). He had been found lying on the street after a drinking bout and had spent the night in jail. The following morning he had complained of pain in the hip and had noted the dislocation. The dislocation was easily reduced with the patient under nitrous oxide anaesthesia supplemented with curare. Buck's extension was maintained for three weeks, and he was then dismissed from the Hospital.

Subsequently this patient was seen on four different occasions, each time with a posterior dislocation of

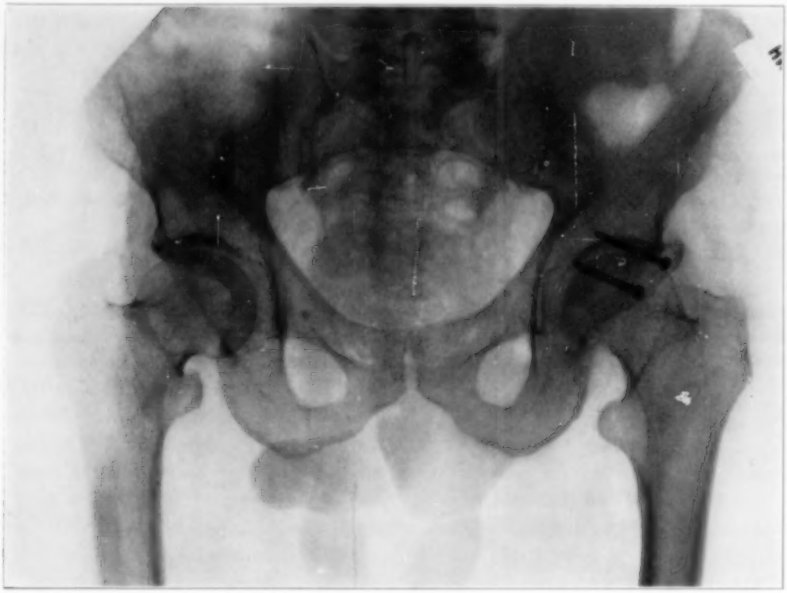

FIG. 5

Roentgenogram made on December 1, 1954, showing buttress of bone held in place with two Vitallium screws.

the left hip. The cause in each instance was a fall on the street or in his room when he was hobbling about without his prosthesis. The dislocations occurred on September 13, 1950, April 5, 1954, August 5, 1954, and November 6, 1954. At no time was there fracture of the acetabulum nor was there more than temporary paraesthesia in the distribution of the sciatic nerve. It is also interesting to note that there was no avascular necrosis of the femoral head and that there were only minimal hypertrophic changes about the hip joints in spite of repeated traumata (Fig. 3).

Because of the increasing frequency of dislocation, an operation was advised and was agreed to by the patient. It was performed, on November 11, 1954, through a posterolateral approach. The deep fascia was split longitudinally between the tensor fasciae latae and the glutaeus maximus muscles. These muscles appeared to be of average development for a man sixty-nine years old. The glutaeus medius, however, may have been somewhat smaller than usual, and the space adjacent to its posterior edge was filled with a large amount of oedematous and hemorrhagic fat. Through this space the surgeon's finger could explore a path of lessened resistance leading directly to the head of the femur. An attempt was made to dislocate the hip posteriorly along this path, but it was found that this could not be accomplished without undue effort. The insertion of the glutaeus medius was next removed from the lateral aspect of the trochanter in continuity with the tendinous origin of the vastus lateralis, as described by McFarland. Retraction of these structures anteriorly revealed a longitudinal rent in the glutaeus minimus. Below this rent there was a similar rent in the posterior superior portion of the capsule of the hip joint (Fig. 4). Synovial fluid escaped from the opening when the hip was moved; and a push-pull manoeuvre on the adducted, flexed, and internally rotated thigh indicated a laxity of the ligaments. Again, however, complete dislocation could not have been produced without violence.

The lateral aspect of the ilium just above and posterior to the acetabulum was freshened with a gouge, and a buttress of bone taken from the left iliac crest was fashioned. The buttress was held in place with two Vitallium screws (Fig. 5). The rents in the capsule and in the glutaeus minimus muscle were closed with a large figure-of-eight suture of fascia lata reinforced with heavy catgut. The other muscles were sutured to their normal attachments.

Postoperatively, the patient was kept in bed for three weeks. Daily exercises were carried out to strengthen the hip muscles, and at six weeks he was allowed to walk with crutches. At the time of this report, he was walking well, had no pain in the hip, and was able to flex the thigh to 90 degrees. Rotation was almost normal.

## SUMMARY

Actual recurrent dislocation of the hip unassociated with acetabular fracture, congenital dysplasia, sepsis, or paralysis is very rare. Before 1945 only seven such instances had been reported. In the eighth case, which has been presented in this paper, the condition was treated by surgical reinforcement of the posterior superior supports of the hip (with a bone block) and by fascial repair of the capsule.

## REFERENCES

1. Bigelow, H. J.: The Mechanism of Dislocations and Fracture of the Hip, pp. 106–108. Boston, Little, Brown and Co., 1900.
2. Cooper, Astley: A Treatise on Dislocations and Fractures of the Joints, pp. 7–8. Boston, T. R. Marvin, 1844.
3. Hamilton, F. H.: A Practical Treatise on Fractures and Dislocations. Ed. 5, pp. 735–737. Philadelphia, Henry C. Lea, 1875.
4. Heully: Cited by Kellogg Speed.[7]
5. McFarland, Bryan, and Osborne, Geoffrey: Approach to the Hip. A Suggested Improvement on Kocher's Method. J. Bone and Joint Surg., **36-B**: 364–367, Aug. 1954.
6. Ombrédanne. Cited by Kellogg Speed.[7]
7. Speed, Kellogg: A Text-Book of Fractures and Dislocations. Covering Their Pathology, Diagnosis and Treatment. Ed. 4, p. 830. Philadelphia, Lea and Febiger, 1942.

# CHONDRODYSTROPHIA CALCIFICANS CONGENITA

## Report of a Case

BY WALTER G. SELAKOVICH, M.D., AND J. WARREN WHITE, M.D., HONOLULU, HAWAII

*From the Shriners' Hospital for Crippled Children, Honolulu*

A relatively rare disorder of infancy which is characterized by numerous punctate or discrete areas of calcification in the epiphyses has been reported by a number of authors and under a variety of names, all of them easily recognizable as the same entity. The condition was first described in 1914 as chondrodystrophia foetalis hypoplastica by Conradi, who considered it an abortive form of chondrodystrophy. Fairbank reported two cases and classified the condition as dysplasia epiphysealis punctata. Hünermann, in 1931, reported it under the name of chondrodystrophia calcificans congenita. A number of reports have named the condition "stippled epiphyses" [2,11,14,16,17].

Hereditary influence does not appear to be present in this condition, which predominately affects females in a ratio of two to one, but familial tendencies have been reported [6,13,15]. The dysplasia is foetal in origin and is usually recognized during the early months of life. Various associated abnormalities are often present. The concurrence of congenital anomalies, such as cataract, cardiac defect, cleft palate, mental deficiency, microcephaly, oxycephaly, dwarfism, foot deformity, and monomelic shortening, has been reported. Flexion contractures, thickened skin, generalized weakness, and poor resistance to infectious processes have also been noted. The patient reported herein demonstrated an associated abnormality of the nose.

The presence of chondral dysplasia together with the roentgenographic picture of irregular density of the epiphyses of various bones is diagnostic if hypothyroidism is not present. The stippling seen in cretinism may be so similar that correction by thyroid therapy may be the only distinguishing characteristic if typical features of cretinism are not prominent. Retardation of ossification of the osseous centers is common in hypothyroidism, whereas the stippling in chondrodystrophia calcificans congenita usually occurs before the time when ossification normally would be expected in the epiphyses [7, 16, 18]. Definite retardation was demonstrated in the case being reported.

Fairbank and others [1,11] have reported death from lung and kidney infections in one-half of the cases before the age of twelve months; however, other reports have not demonstrated such a poor prognosis [5,15]. The patient being presented is especially unusual in that she has led a relatively healthy life for nearly twelve years.

A maternal history of rubella, or other predisposing factors during pregnancy, has not been noted as a possible etiological influence in this condition [5,6].

The sites of predilection, roentgenographically, are the upper and lower ends of the femur, the tibia, and the fibula, the upper end of the humerus, the lower end of the radius and ulna, the tarsal and carpal bones, and occasionally the pelvis, vertebrae, and the rib cartilages. The phalanges have seldom been noted to be involved. In a case reported by Haynes and Wangner there was extensive stippling of nearly all epiphyses.

The importance of the case now being presented lies in the fact of survival and the known result of the epiphyseal dysplasia and dystrophy after eleven years and three months. Fairbank noted in a patient who had reached the ninth year, and Raap, in three siblings observed up to four, five, and six years of age, that the discrete areas of calcific density coalesce within the epiphyses, and that the involved epiphyses were entirely ossified at approximately the same time as the opposite uninvolved epiphyses. The result of the abnormal growth and nutrition, however, may be shortening of the entire extremity,

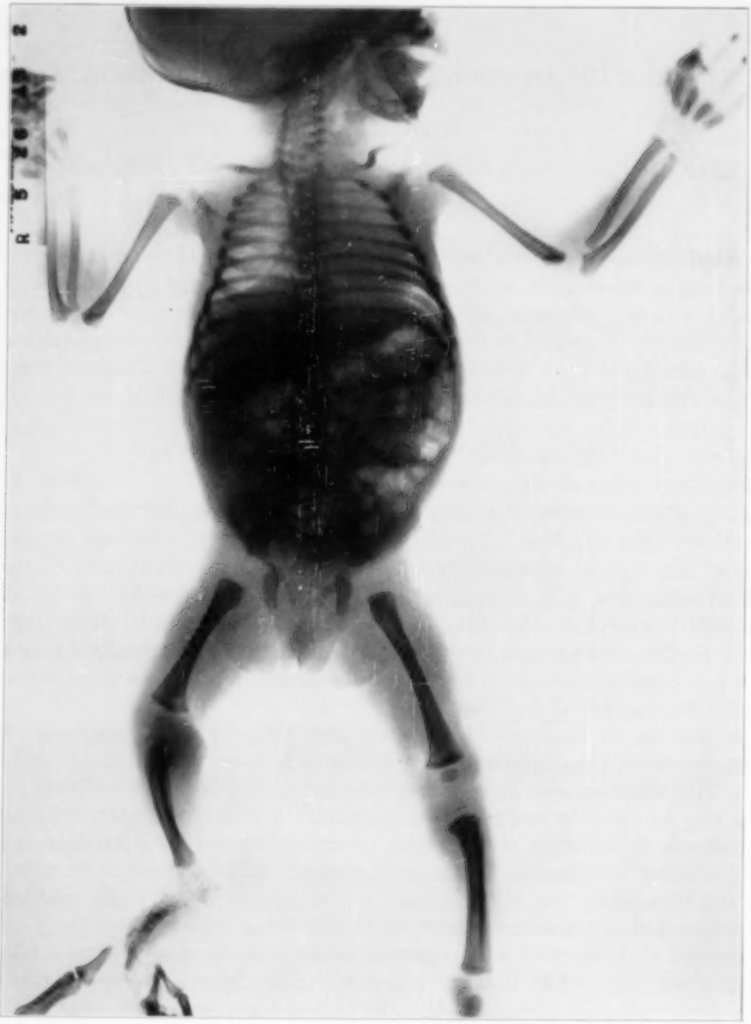

FIG. 1

Roentgenogram made at twenty-five days. Stippling is noted about the right acetabulum, right pubis, sacrum, and coccyx, distal epiphysis of the femur, the proximal and distal ends of the tibia and fibula, and in the tarsal bones of the right lower extremity. The stippling about the calcaneus appears peripheral and seems to outline the bone, as does the stippling of the ischium and pubis.

smallness and deformity of individual bones, and abnormality of the part as a whole secondary to the bone changes. Close contact with the patient now being reported over a number of years has confirmed these observations convincingly. The case is presented as a definite aid in determining the late deformities to be expected and, therefore, may have a bearing on the type of orthopaedic treatment which may well be given.

Pathological studies of stippled epiphyses, demonstrated at postmortem examination by Hässler and Schallock, revealed circumscribed polymorphous chalky deposits in the cartilage, with areas of calcification and new-bone formation replacing the chalky material. Raap described fibrosis of the periosteum with underlying cartilage formation and calcification, and the formation of osteoid in the deeper layers of the cartilage cells. Haynes

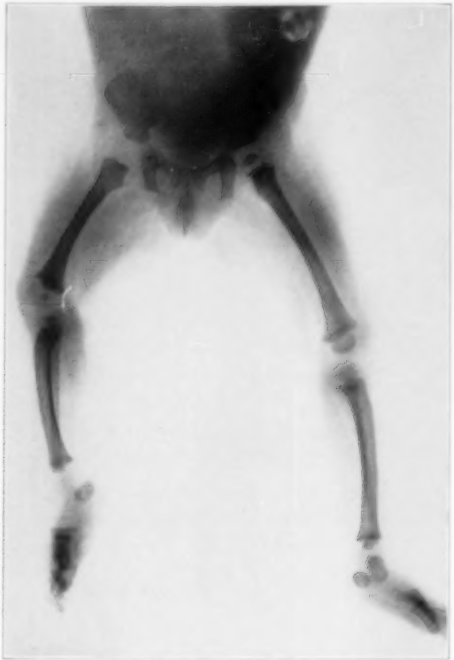

FIG. 2

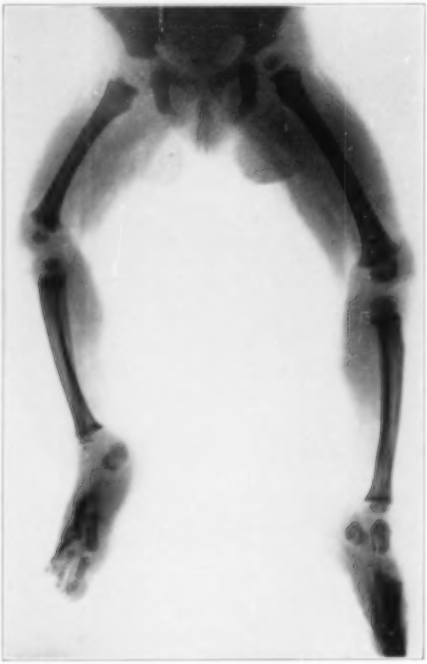

FIG. 3

Fig. 2: Roentgenogram made when the patient was thirteen months old. Note that stippling is very much less but is still present in most of the places where it was noted in profusion at birth. There is minimal stippling in the left foot. (Note: In Figs. 2, 3, and 4, the stippling is barely seen, if it is seen at all. It was so finely granular in the roentgenograms that it was impossible to reproduce.)

Fig. 3: At one year and eight months, the ossification center of the right femoral capital epiphysis has appeared as an elongated, flat, irregular area demonstrating beginning ossification. The calcaneus is nearly completely ossified. There is still some stippling in most of the regions in which stippling had been present previously but the amount is greatly reduced due to ossification.

and Wangner pointed out the disturbance noted by Cocchi in vascularization of the epiphyseal cartilage, and of the cartilaginous anlage of the small bones of the extremities. The cartilage columns show degrees of divergence from the usual parallel arrangement. The discrete calcific areas appear as deposits of calcium at the terminal portion of the abnormally disposed vessels. However, it has not been determined what constitutes the underlying pathological process.

Lund demonstrated fibrous replacement of the muscles, which probably explains the basis of the contractures in some cases.

The degree of involvement has varied considerably among the reported cases, one or more extremities being affected. Monomelic involvement was reported by Fairbank and this was eventually demonstrated to be the case with our patient. Early roentgenograms revealed the left foot and right wrist to be involved, with no apparent stippling or other involvement in the vertebral column, but the above areas "cleared" early and no resultant abnormalities occurred except a mild degree of hypoplasia of the carpal bones of the right wrist, and extensive chondrodysplasia of the vertebral bodies. The entire right lower extremity, in which generalized involvement had been demonstrated, persisted in showing the effects of this anomaly.

Laboratory study has failed to reveal abnormalities in the blood picture and other tests have been noted to be normal.

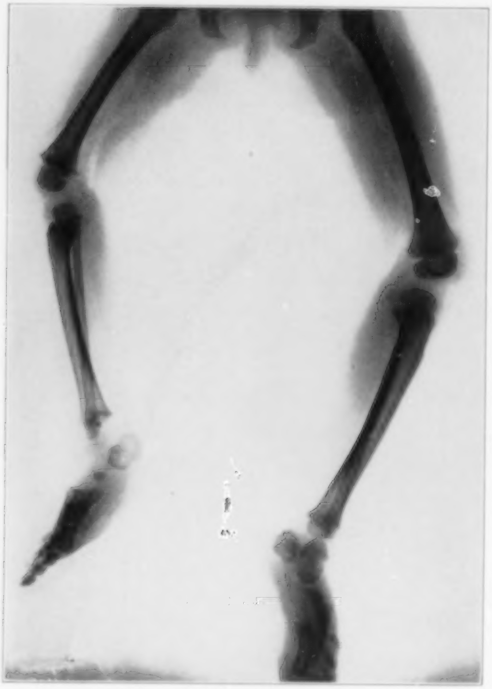

FIG. 4

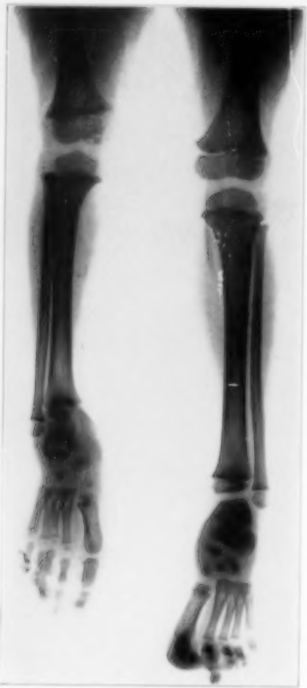

FIG. 5

Fig. 4: At two years and eight months, the calcaneus is completely ossified, and the stippling is no longer seen in the cuboid, which is extensively ossified. Stippling of the right navicular is noted for the first time. The epiphyses of the long bones are well formed but the ossification centers on the right are for the most part smaller. The right lower extremity is again noted to be considerably shorter.

Fig. 5: At three years and eight months the shortening of the right lower extremity is marked. The areas of fine stippling have disappeared and only the coarse irregularity and relatively small size of the ossification centers in the epiphyses remain at the site of stippling. Some small discrete areas of increased density are to be noted within the talus, as well as an enlarged navicular associated with delay in the appearance of the ossification center of the cuboid and the lateral two cuneiforms.

## CASE REPORT

G. M., aged eleven years and three months, a Chinese-Caucasian-Hawaiian female, was first seen at the Wailuku Clinic in Waihee, Maui, Hawaii, at the age of twenty-five days because the mother had noted a difference in the length of the lower extremities. The right lower extremity seemed definitely smaller than the left but was otherwise normal in appearance. Roentgenograms at that time (Fig. 1) revealed discrete areas of calcific density in the acetabulum, in the sacrum and in the coccyx, in the right pubic bone, the distal femoral, the proximal and distal tibial and fibular epiphyses, and in the tarsal bones of the right lower extremity. Definite retardation in longitudinal growth was noted. The child was seen again at one month, and thereafter at three-month intervals for the first year. Examinations at yearly intervals were performed until she was seven years old. At that time the child was admitted to the Shriners' Hospital for the first time for correction of 9.5 centimeters of shortening of the right lower extremity. A lift to help compensate for the shortening was the only therapy given before the first admission. The child led a normal, healthy existence and demonstrated only the abnormality described in a normally functioning extremity. The nose was noted to be saddle-shaped but caused no symptoms.

Lengthening of four centimeters of the right femur was obtained during the first admission. An epiphyseodesis of the left lower femoral epiphysis became necessary and was performed at the second hospital admission, when the patient was eight years and eleven months old.

The third hospital admission, when the patient was eleven years and two months old, was for epiphyseodesis of the proximal epiphyses of the left tibia and fibula because of six centimeters of shortening of the right lower extremity. Complete re-evaluation of the case, including repeated vaginal smear and urinalysis as well as the Schick and Mantoux tests, demonstrated normal physical and laboratory findings except for the abnormality of the nose and the abnormality of the right lower extremity. Biopsy was not done in this case.

Normal development physically and mentally had taken place, and the child had led a relatively normal, healthy life. Associated with the shortening of the right lower extremity was a valgus deformity of the foot with symmetrical hypoplasia of all structures, but no evidence of joint dysfunction or contracture. There had been no change in the abnormality of the nose, and there were no complaints relative to it.

In a review of the roentgenograms made at each visit to the Clinic and at each hospitalization, the pattern of the stippling, its progression into complete calcification and ossification, and the eventual result secondary to this anomaly are well demonstrated (Figs. 2 to 8).

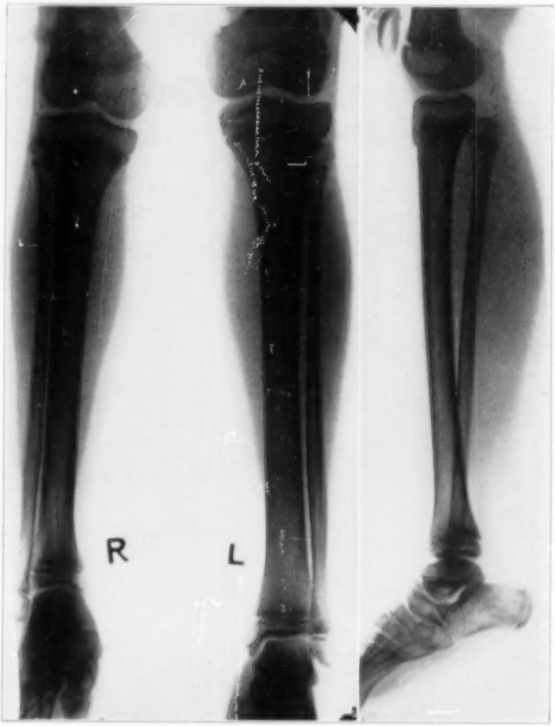

Fig. 6-A Fig. 6-B

At eleven years and three months, there are complete ossification and fairly normal-looking epiphyses and tarsal bones. An accessory bone of the talus (or an unfused area) is noted at the dorsolateral aspect of the bone in the lateral view. Limb-length discrepancy and general hypoplasia of the osseous structures are again noted.

## DISCUSSION

It is interesting to note that stippling occurred in the right carpal and left tarsal bones; yet these areas returned to relative normalcy early and no resultant abnormalities developed, except for slight hypoplasia of the right carpal bones, especially the capitate. The vertebral bodies had never demonstrated stippling, but definite chondrodystrophic changes did develop, resulting in marked abnormalities which are quite similar to those seen in other forms of chondrodysplasia.

A definite tendency for the stippling to occur about the periphery, rather than centrally, was noted, and in some areas, especially in the calcaneus, it appeared as such while ossification was present centrally. Essentially no abnormalities resulted in the acetabulum, the sacrum, the coccyx, or the pubic bones, all of which, on the right side, had demonstrated stippling. Retardation in the osseous centers with slower ossification of an irregular nature occurred, but completion of the ossification was noted at approximately the same time as the normal side. The proximal end of the left femur had not been noted to be involved; however, at the present time, the neck is short and thick and the head is large. The changes are similar, but of a lesser degree, to those in the opposite side. The two centers of ossification of the pubic bones eventually fused, the left earlier than the right, so that the area of discontinuity could not be seen in the last roentgenograms. The stippling of the right talus progressed from fine discrete calcifications to multiple larger areas and finally into a completely ossified bone with an accessory bone adjacent to it. Retardation of full ossification of all tarsal bones of the right foot was demonstrated in the roentgenograms.

## SUMMARY

In summary, the authors feel that this case, presented roentgenographically, demon-

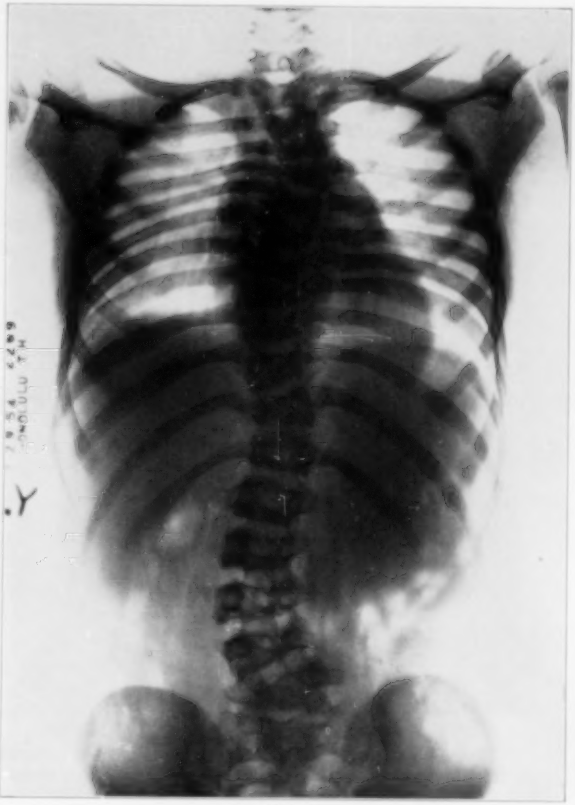

FIG. 7

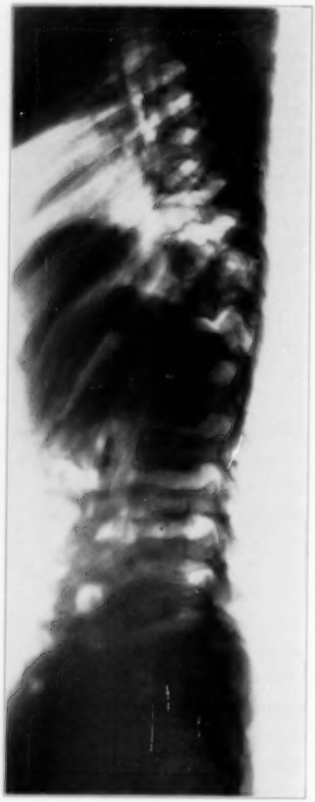

FIG. 8

Fig. 7: Marked congenital anomalies are noted throughout the entire spine with secondary scoliosis present to a moderate degree.

Fig. 8: Wedging anteriorly, as well as posteriorly, is noted in the vertebral segments with irregularities in the shape of the bodies. The thoracic spine is involved more severely. The abnormality of the vertebral bodies is notable throughout.

strates, as in a slow-motion picture, the uninterrupted course of events in chondrodystrophia calcificans congenita. The sequence of events leading to fusion of the areas of stippling of the epiphyses is demonstrated. It appears that there is a definite variation in the degree of involvement in the different cases reported, and that those cases with marked involvement and with associated anomalies have a poorer prognosis. The authors feel that the manifestations constitute a definite chondrodysplasia with variation in potentiality in regard to the eventual effect on completion of development.

## REFERENCES

1. BATEMAN, DONALD: Two Cases, and Specimens from a Third Case, of Punctate Epiphyseal Dysplasia. Proc. Roy. Soc. Med., **29:** 745–747, 1936.
2. BLUXTON, ST. J. D.: A Dwarf with Stippled Epiphyses. Proc. Roy. Soc. Med., **23:** 1329–1331, 1930.
3. COCCHI, U.: Chondroangiopathia Calcarea seu Punctata. *In* Lehrbuch der Röntgendiagnostik, von H. R. Schinz, W. E. Baensch, E. Friedl, und E. Uehlinger. Band I, Teil 2, S. 662. Stuttgart, Georg Thieme, 1950.
4. CONRADI, ERICH: Vorzeitiges Auftreten von Knochen- und eigenartigen Verkalkungskernen bei Chondrodystrophia fötalis hypoplastica. Histologische und Röntgenuntersuchungen. Jahrb. f. Kinderheilk., **80:** 86–97, 1914.
5. COUGHLIN, E. J., JR.; GUARE, H. T.; and MOSKOVITZ, A. J.: Chondrodystrophia Calcificans Congenita. Case Report with Autopsy Findings. J. Bone and Joint Surg., **32-A:** 938–942, Oct. 1950.

6. Fairbank, H. A. T.: Dysplasia Epiphysialis Punctata. Synonyms—Stippled epiphyses, Chondrodystrophia calcificans congenita (Hünermann). From an Atlas of General Affections of the Skeleton. J. Bone and Joint Surg., **31-B:** 114–117, Feb. 1949.
7. Geyman, M. J.: An Unusual Manifestation of Epiphyseal and Joint Pathology in a New-Born Infant. Am. J. Roentgenol., **26:** 868–870, 1931.
8. Hässler, E., und Schallock, G.: Chondrodystrophia calcificans. Monatsschr. f. Kinderheilk., **82:** 133–157, 1940.
9. Haynes, E. R., and Wangner, W. F.: Chondroangiopathia Calcarea seu Punctata. Radiology, **57:** 547–550, 1951.
10. Hünermann, Carl: Chondrodystrophia calcificans congenita als abortive Form der Chondrodystrophie. Zietschr. f. Kinderheilk., **51:** 1–19, 1931.
11. Lightwood, R. C.: Congenital Deformities with Stippled Epiphyses and Congenital Cataract. Proc. Roy. Soc. Med., **24:** 564–566, 1931.
12. Lund, E.: Metaphyseal Dyscrasia. Proc. Roy. Soc. Med., **36:** 381, 1942.
13. Maitland, D. G.: Punctate Epiphyseal Dysplasia Occurring in Two Members of the Same Family. British J. Radiol., **12:** 91–93, 1939.
14. McCullough, J. A. L., and Sutherland, C. G.: Epiphyseal Dysplasia Puncticularis (Stippled Epiphyses). Radiology, **34:** 131–135, 1940.
15. Raap, Gerard: Chondrodystrophia Calcificans Congenita. Am. J. Roentgenol., **49:** 77–82, 1943.
16. Reilly, W. A., and Smyth, F. S.: Stippled Epiphyses with Congenital Hypothyroidism (Cretinoid Epiphyseal Dysgenesis). Am. J. Roentgenol., **40:** 675–681, 1938.
17. Sears, W. G.: Dwarfism with Stippled Epiphyses. British J. Child. Dis., **28:** 290–295, 1931.
18. Wilkins, Lawson: The Diagnosis and Treatment of Endocrine Disorders in Childhood and Adolescence. Springfield, Illinois, C. C. Thomas, 1953.

# GIANT-CELL TUMOR OF THE PELVIS AT THE ACETABULUM, ILIUM, ISCHIUM, AND PUBIS

BY GEORGE ROBERT DAWSON, JR., M.D., FLORENCE, SOUTH CAROLINA

This is a case of a giant-cell tumor of the acetabulum which was curetted and packed with bone chips. The patient recovered almost normal hip motion and four years later was successfully delivered by Caesarean section. We believe this to be the first such case to be reported.

## CASE REPORT

A fourteen-year-old white girl whose chief complaint was "left hip pain" was first seen on February 12, 1948. The onset of pain had occurred six months previously. The patient's weight had dropped from 106 to eighty-nine pounds.

Examination showed a slender girl who walked with a severe protective left limp, marked abductor lurch and a 15 degree list of the trunk to the right. The spinal motion was notably limited. On abdominal examination a mass, round and not tender, was palpated which extended one inch above the left inguinal ligament.

The patient had the following motion of the left hip: straight-leg raising, 60 degrees; flexion, 100 degrees; adduction, 50 degrees; abduction, none; internal rotation, none; external rotation, 5 degrees.

The results of the remainder of the physical examination were negative. The laboratory findings were within normal limits. A roentgenogram (Fig. 1) showed an area of destruction, irregular in outline, involving the left ilium, ischium and pubis. An area of decreased density was centered above the acetabulum. This area extended laterally from three-quarters of an inch inside the outer acetabular margin; upwards to one and one-half inches above the acetabulum, and downward. The lower margin could not be well traced because here the shadow of the pubis overlapped the ischium. A large, elongated, elliptical mass of joint calcification could be seen medially to this area of bone destruction. This calcification was denser at its edges. The medial edge of the mass extended to the mid-line, inferiorly to within one-eighth inch of the superior rami, superiorly to the first sacral segment.

Based on this roentgenographic appearance a diagnosis of giant-cell tumor of the ilium, ischium, and pubis at the acetabulum was made. No other diagnosis was entertained.

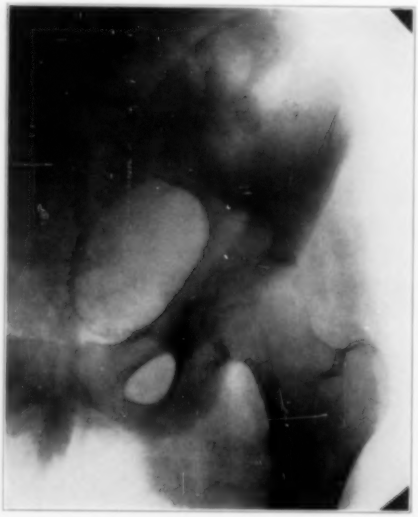

FIG. 1

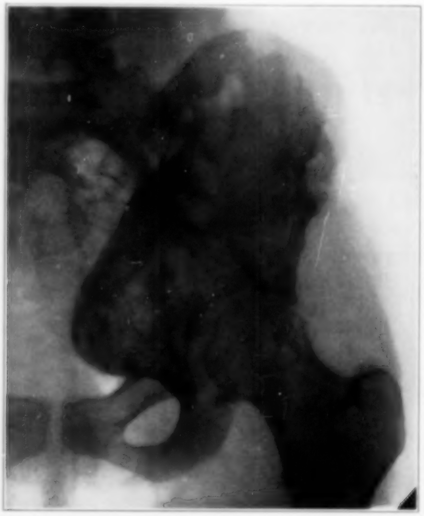

FIG. 2

Fig. 1: First roentgenogram made March 4, 1948. Note area of bony destruction about the acetabulum and the wall of the cyst extending almost to the mid-line.

Fig 2: Roentgenogram made March 2, 1949, one year after operation. The consolidation of bone chips is now complete.

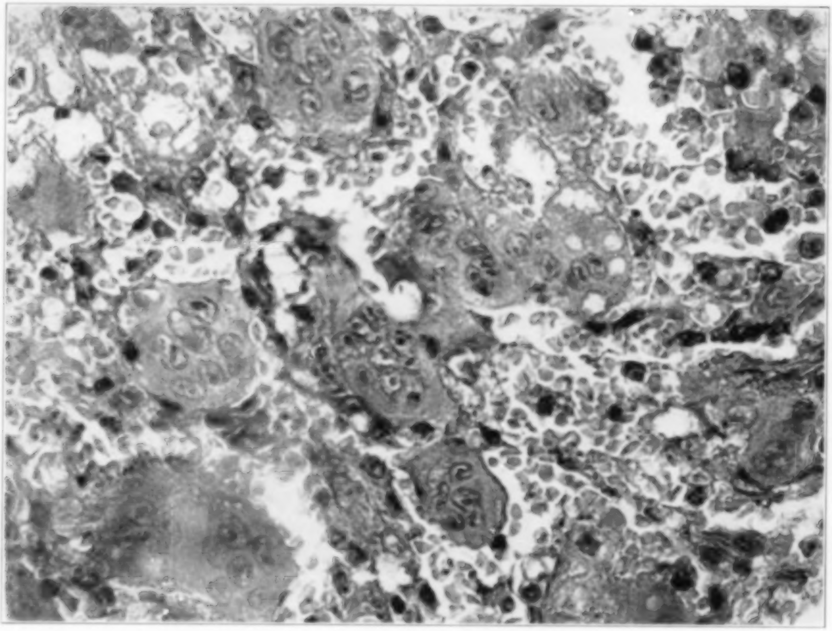

FIG. 3

Photomicrograph (× 600) of a representative section of the giant-cell tumor removed from the ilium above the acetabulum. The giant cells and stroma are typical.

The patient was admitted to The McLeod Infirmary and, after consultation with the general surgical department on the question of operative approach, the operation was performed on March 5, 1948. An extensive Smith-Petersen incision was made. The extremely thin-walled, cyst-like mass was quickly entered above the acetabulum because the bony shell was eroded. The mass looked and felt like a typical giant-cell tumor. It was filled with dark blood and pulpy tissue, perhaps a little firmer than granulation tissue. Pieces of this tissue were grayish-red to dark red and contained bone. In the tissue were some smooth-lined cysts up to one centimeter in diameter enclosed in thin bony walls.*

After all this tissue had been cleaned out, the exact extent of the giant-cell tumor was studied.

The cyst extended exactly to the mid-line. The wall of the cyst here was thick enough to make it possible to curette gently and avoid entering the peritoneal cavity. The cyst extended to within one-quarter of an inch of the symphysis pubis and as high as the first sacral segment (Fig. 1). The extent of bone destruction was greater than the roentgenogram would lead one to believe. The bone destruction extended down to the acetabular cartilage which was exposed from a point three-quarters of an inch from the outer edge of the acetabulum medially and inferiorly as far as the eye could see or the finger could feel. The destruction extended medially around the rim of the pelvis. Superiorly it extended one and three-quarters inches above the acetabulum. The cyst wall extended two inches higher. The entire area of bone destruction and the cyst wall were curetted, very gently on the medial side near the mid-line.

Part of the wing of the ilium was removed and prepared as bone chips, three-sixteenths to five-sixteenths of an inch in diameter. A total of about six ounces of chips was packed into the entire area of bone destruction and of the cyst. A good deal of oozing of blood occurred during the operation. Five hundred cubic centimeters of five per cent. glucose in normal saline and 500 cubic centimeters of citrated blood were given intravenously during the operation.

Convalescence was uneventful. A spica cast was applied before discharge from the Hospital fifteen days after operation. The cast was removed seven weeks after operation. The patient was allowed up on crutches three and one-half months after operation. She gained weight rapidly. The limp and the pain disappeared. Hip motion increased rapidly.

One year after operation the roentgenogram (Fig. 2) showed great consolidation of the bone chips. The patient walked, unaided, without limp or trunk list. Hip motion was nearly normal.

On September 17, 1951, the patient was seen again. She was now seventeen years old, married and five months pregnant. Examination of hip motion showed the following: straight-leg raising, 85 degrees; flexion, 110 degrees; abduction, 10 degrees; adduction, 50 degrees; internal rotation, 5 degrees; external rotation, 25 degrees.

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* See report of the pathologist.

A normal baby was delivered by Caesarean section on January 15, 1952. Convalescence was uneventful.

## REPORT OF THE PATHOLOGIST

The specimen consisted of a number of grayish-red to dark red pieces of pulpy tissue in which there was bone.

One of the sections of tissue measured 2.3 by 2.1 by 1 centimeters. There were two small smooth-lined cysts in this tissue each of which measured about one centimeter. About half of each cyst wall was present. There was a thin bony shell about the walls of the cyst. These cysts were enclosed in pulpy dark-red tissue.

An island of bone that measured 1.8 by 1.5 by 0.5 centimeters, contained two cysts that measured respectively 0.3 and 0.5 of a centimeter.

### *Microscopic*

Sections of the tissue from the ilium showed a fibrocellular matrix in which there were numerous giant cells. These giant cells appeared to develop in the fibrous matrix. They showed round to ovoid granular nuclei and an acid-stained cytoplasm. The fibrous tissue was cellular in places and showed numerous small vessels. There were extensive areas of hemorrhage and some bony spicules along which osteoblasts appeared in normal arrangement. Within these bony spicules there were regularly dispersed bone cells of regular size, shape, and staining quality.

In some areas the substance of the tumor appeared very vascular with numerous blood spaces that were lined by flattened compressed endothelium. About them there was a type of stroma described above containing giant cells, some round cells resembling lymphocytes, and cells which suggested endothelial structure because of the relationship to the vessels.

### *Diagnosis*

Benign giant-cell tumor of left ilium.

# LARGE CYST OF THE MEDIAL MENISCUS OF THE KNEE JOINT

## Report of a Case

BY FRANK O. McGEHEE, M.D., AND BRUCE M. CAMERON, M.D., HOUSTON, TEXAS

This case is reported, not only because a cyst of the medial meniscus is rare, but also because it was larger than any which the authors have noted in the literature.

Relatively few cysts of the medial menisci have been recorded, and it was not until 1933 that a series of any appreciable size was reported by Colonna. He had collected ten cases from the literature and added one of his own. Ollerenshaw, two years later, reported six in a series of forty-two meniscectomies and stated that the series was larger than any reported up to that time. Bennett and Shaw, in 1936, collected twenty-three cases and added two of their own. Smillie, in 1951, reported that he had found twenty cysts of this type during the course of 1,500 arthrotomies in which one or both menisci had been removed. Bonnin, in 1953, reported seven cases.

These cysts occur less frequently than cysts of the lateral meniscus, the ratio being approximately one to five [2,8,9]. They vary in size (from one to five centimeters) and are usually larger than cysts of the lateral meniscus, because they have more room to expand [9]. They are found more frequently in males than in females [1,2,3,6,8,9]. Their etiology is unknown, but most authors believe that they are the result of a process of degeneration and are not true cysts *per se* and that the lining represents a condensation of the cells of the meniscus that have been crowded together [1,4,6,9]. Others think that they are true cysts, and a number of theories of etiology, such as synovial or congenital implantation, or arteriolar change, have been advanced [1,3,7]. All agree that excision *in toto* with the cartilage is the method of treatment.

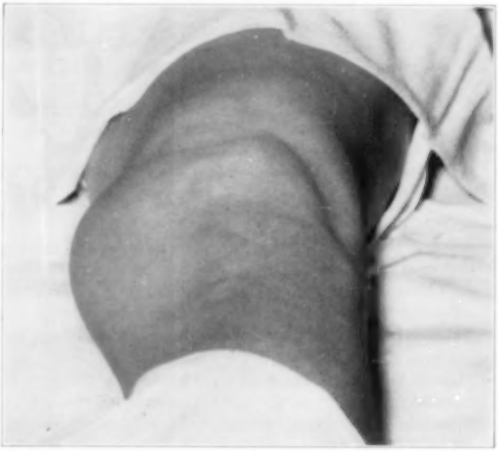

FIG. 1

Photograph of the left knee showing a large mass on the medial aspect of the knee.

CASE No. 11013. Mrs. C. J. B., sixty-eight years old, a housewife, was seen on June 14, 1954, complaining of pain, swelling, and disability referable to the left knee. In October 1952, she fell, striking the medial side of the knee, but at the time she had thought little about it. About four months later, she noted arthralgia and received conservative treatment for hypertrophic arthritis. In August 1953, she first felt a mass over the area of the medial meniscus and, at that time, there was considerable pain but no swelling or disability. The pain increased until December 1953, at which time she required medication for relief. The mass gradually enlarged, and during the last six months prior to admission it measured 12.5 centimeters in diameter. In the last three months before admission the pain became intolerable, and during the last three weeks, swelling appeared in the joint and she was unable to walk.

General physical examination, including blood pressure, chest roentgenogram, urinalysis, and complete blood count, was normal. The patient complained bitterly about the knee and was unable to bear weight on the left lower extremity. The knee was swollen, the superficial veins were distended, and on the

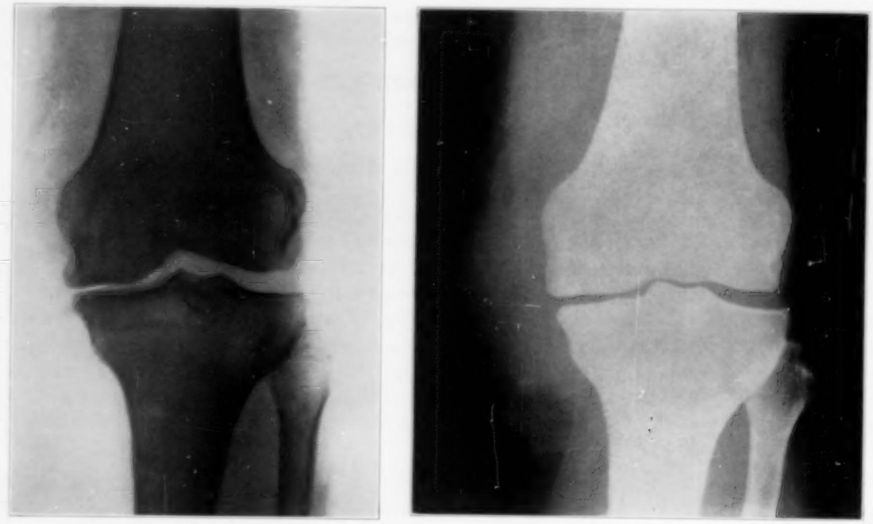

FIG. 2-A FIG. 2-B

Roentgenograms of the left knee.

Fig. 2-A shows erosion of the medial margin of the medial condyle of the tibia and hypertrophic changes commensurate with the age of the patient.

Fig. 2-B shows details of soft parts. The outline of the cyst over the medial aspect of the joint is clearly indicated.

medial side there was a hard, fixed, tender mass, measuring ten by 12.5 centimeters, with areas of cyst formation (Fig. 1). It changed little with motion. Flexion was limited to 90 degrees and extension to 160 degrees. The collateral and cruciate ligaments were intact and the neurovascular status was normal.

Roentgenograms (Figs. 2-A and 2-B) demonstrated a large, non-calcified, soft-tissue mass over the medial side of the joint, which caused erosion of the medial tibial condyle. Hypertrophic changes commensurate with the patient's age were noted.

Operation was advised and performed on June 19, 1954, at the Methodist Hospital. A pneumatic tourniquet was used, and the lesion was exposed through an Eggers' incision. The purpose of this incision is to allow adequate exposure of either the medial or lateral compartment of the knee, particularly when wide exposure of one of the menisci is required. It is used only when it is reasonably certain that the pathological condition is localized to one of those areas, since it does not allow complete exploration of the knee joint.

The skin incision was started one finger-breadth in front of the medial hamstring tendons on a level with the superior pole of the patella and extended distally and anteriorly to within one finger-breadth of the patellar tendon at the joint line. The skin flaps were reflected to allow exposure of the capsule and a transverse incision was made through this at the joint line, care being taken to avoid the tibial collateral ligament but yet to utilize the entire exposure obtained by the skin incision. The synovial membrane was incised in the same line, thus exposing the joint compartment and the periphery of the cartilage. The infrapatellar branch of the saphenous nerve in the distal portion of the incision should be retracted and preserved if possible.

A large cyst was found in the medial meniscus and had expanded peripherally in all directions, stretching the overlying capsule and tibial collateral ligament. The latter structure had to be detached (thus modifying the Eggers' approach), revealing erosion of the tibia. The cartilage and cyst were removed, the ligament was re-attached with catgut, and the wound was closed in layers.

Postoperatively, the knee was immobilized in a cylinder cast in the extended position for three weeks to allow healing of the capsule.

The gross specimen consisted of the cyst and meniscus, measuring seven by six by four centimeters. The cut surfaces showed typical cystic areas filled with mucoid material. The microscopic sections revealed large areas of mucoid degeneration interspersed in the fibrous tissue of the cartilage. No true cyst lining could be found, but areas of condensation of the fibrocartilaginous cells could be seen, giving the appearance of an epithelial lining.

The patient's postoperative course was satisfactory and, two weeks following operation, serum was evacuated from the dead space.

Ten weeks later, the patient was free from pain and ambulatory, with a stable knee.

## DISCUSSION

This cyst of the medial meniscus was reported because it was extremely large and painful. The distention of the capsule and the tibial collateral ligament probably accounted for the early pain, but the intractable pain, noted later, was probably due to erosion of the tibial periosteum. Excision of the cyst and meniscus *in toto* resulted in recovery.

## REFERENCES

1. Bennett, G. E.: Cysts of the Semilunar Cartilage. Am. J. Surg., **43**: 512–518, 1939.
2. Bennett, G. E., and Shaw, M. B.: Cysts of the Semilunar Cartilages. Arch. Surg., **33**: 92–107, 1936.
3. Bonnin, J. G.: Cysts of the Semilunar Cartilages of the Knee-Joint. British J. Surg., **40**: 558–565, 1953.
4. Colonna, P. C.: Cysts of the Internal Semilunar Cartilage. J. Bone and Joint Surg., **15**: 696–701, July 1933.
5. Eggers, G. W. N.: Personal communication.
6. Ghormley, R. K., and Dockerty, M. B.: Cystic Myxomatous Tumors about the Knee: Their Relation to Cysts of the Menisci. J. Bone and Joint Surg., **25**: 306–318, Apr. 1943.
7. King, E. S. J.: The Formation of Ganglia and Cysts of the Menisci of the Knee. Observations on the Golgi Apparatus. Surg., Gynec., and Obstet., **70**: 150–156, 1940.
8. Ollerenshaw, Robert: A Further Note on the Development of Cysts in Connection with Semilunar Cartilages of the Knee-Joint. British J. Surg., **23**: 277–279, 1935.
9. Smillie, I. S.: Injuries of the Knee Joint. Ed. 2. Baltimore, The Williams & Wilkins Co., 1951.

# TUMOR OF THE WRIST OF ANOMALOUS MUSCLE ORIGIN

BY ROBERT E. VAN DEMARK, M.D., SIOUX FALLS, SOUTH DAKOTA

In cases of soft-tissue enlargement on the volar aspect of the wrist, the differential diagnosis should include an anomalous palmaris longus as well as the usual types of synovitis and the soft-tissue tumors. Anomaly of this muscle is hardly mentioned in the literature relating to wrist tumors, and reported cases of this condition are rare[1]. In the future, cases will probably be presented to orthopaedic surgeons with greater frequency, in response to public education for the early recognition of tumors. This latter factor was present in the following case.

A white male, fourteen years old, was referred on September 18, 1953, with a provisional diagnosis of cyst of the left wrist. The condition had first been noticed nine months previously, after he had been struck on the wrist while playing ball. There was no interference with function and no persistent pain. Examination revealed a definite, slightly elevated, non-tender, soft-tissue enlargement on the volar aspect of the wrist; this enlargement was most evident on dorsiflexion (Fig. 1). The opposite wrist was normal in appearance, and roentgenographic examination of the affected area showed no abnormalities. The patient and the referring physician were advised that the process was probably benign and that an operation should be performed at a date of convenience.

The patient (Case No. 146,-750) was operated upon at the Sioux Valley Hospital on September 26, 1953. After a pneumatic tourniquet had been placed on the arm, an L-shaped incision was made along the distal and medial margins of the enlargement. On retraction of the skin and subcutaneous tissue, it was found that the tendon of the palmaris longus was absent; in its place was a strap-like muscle belly (Fig. 2) measuring approximately 0.8 centimeter in thickness and three centimeters in width at its maximum dimensions. The muscle fibers coursed in a longitudinal direction. Distally the muscle was attached at two points, at a medial point, in the palmar fascia superficial to the proximal margin of the transverse carpal ligament, and at a lateral and more distal point, in the palm near the base of the thenar eminence (Fig. 2). The muscle became tendinous near the latter point and was not explored throughout its insertion. The adjacent flexor carpi ulnaris tendon,

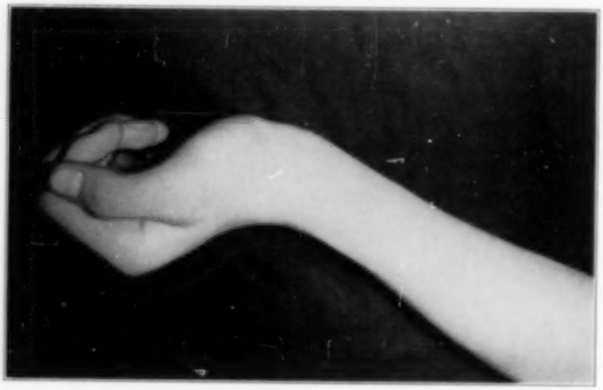

FIG. 1

Photograph of the left wrist and hand, showing the enlargement over the volar aspect of the wrist.

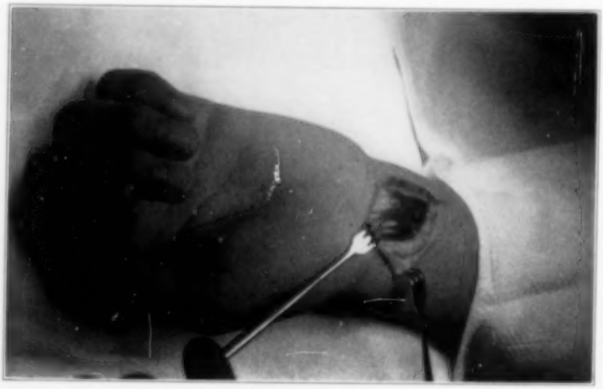

FIG. 2

Findings on surgical exposure of the wrist area, showing the muscular palmaris longus and its bifid insertion.

ulnar artery, and ulnar nerve were entirely normal in appearance. On elevation of the muscle belly the median nerve and flexor tendons were visualized, and again no abnormalities were noted. The structures lateral to the muscle belly were not explored, nor was the muscle explored more proximally, since further incision would have been required and the likelihood of practical benefit seemed remote. The muscle itself was entirely normal in appearance and was not removed. After strict hemostasis had been secured, the wound was closed with interrupted sutures, and a pressure dressing and a splint were applied.

The incision healed by primary intention. The function of the wrist was subsequently normal, and there was no limitation of activity. The patient was last seen on September 23, 1954, because of a football injury to the right thigh. He had been playing basketball, baseball, and football since his wrist operation. The wrist had not bothered him at any time, and he and his parents were pleased with the postoperative result. The wrist itself remained unchanged in appearance.

## DISCUSSION

In an excellent, well-documented, anatomical study of the palmaris longus, Reimann and his associates pointed out that the positions of the fleshy portion and of the tendon may be reversed, the former being at the distal end. This fact has largely escaped attention in the clinical literature, particularly the English literature. The palmaris longus is one of the most variable muscles in the human body. In a fixed specimen, the contractile elements of the muscle may be as much as a centimeter thick as the wrist is approached and in a viable muscle they may well be thicker. In contrast to two previously reported cases in which the muscle belly had been excised at the wrist for relief of pain[1], the muscle was not excised in this case and the result was excellent. In cases of possible anomalous palmaris longus muscle, the diagnosis cannot be established with absolute certainty unless surgery is performed to visualize the muscle belly, thus ruling out other causes of enlargement.

Note: Dr. Steele F. Stewart recently reported an additional case of this condition. In this case, there was some pain, and a swelling appeared on the volar aspect of the wrist upon active flexion. (Proceedings of the Sixth Congress of the International Society of Orthopaedic Surgery and Traumatology. *The Journal of Bone and Joint Surgery*, **36-B:** 689–690, Nov. 1954.)

## REFERENCES

1. Madsen, E.: Musculus Palmaris Longus Inversus. To Symptomgivende Tilfaelde. Nordisk Med., **34:** 855–856, 1947.
2. Paglial, E.: Sopra una Variazione Muscolare dell'Avambraccio Riferibile al Musculo Palmare Lungo. Monitore Zool. Italiano, **40:** 231-236, 1929.
3. Reimann, A. F.; Daseler, E. H.; Anson, B. J.; and Beaton, L. E.: The Palmaris Longus Muscle and Tendon. A Study of 1600 Extremities. Anat. Rec., **89:** 495–505, 1944.

# MODIFIED DENIS BROWNE SPLINT FOR UNILATERAL CLUB-FOOT TO PROTECT THE NORMAL FOOT

BY STUART THOMSON, M.D., TORONTO, ONTARIO, CANADA

*From the Hospital for Sick Children, Toronto*

For many years there has been a good deal of anxiety about the damage done to the normal foot during the treatment of unilateral club-foot with the Denis Browne splint. In a fair number of patients the so-called normal foot becomes a flat foot. Of course, in some patients the other foot is actually a congenital flat foot; in these patients this pronation is aggravated by the Denis Browne splint.

During the past year the splint has been changed by the substitution of a universal joint. This joint allows the normal foot to assume the extremes of the valgus, varus, flexion, and extension positions. Originally rotatory motion was allowed as well, but this motion proved to be unnecessary and even detrimental.

The universal joint is simply the universal attachment which comes with the wrenches of an automobile tool kit. One end of the joint is fastened to the crossbar of the splint with a bolt and lock-washer (or it may be fastened on permanently). The other end is fastened either to the metal footplate or to the boot. Because of the presence of the joint, the footplate or boot for the normal foot is one and five-eighths inches higher than the footplate or boot for the club foot. The value of the universal joint is that it allows the normal foot much freer and more vigorous kicking while, at the same time, holding it in a normal anatomical position. Furthermore, the greater distance of the patient's foot from the crossbar due to the interposition of the universal joint adds more thrust and so makes the splint more effective in correcting club-foot.

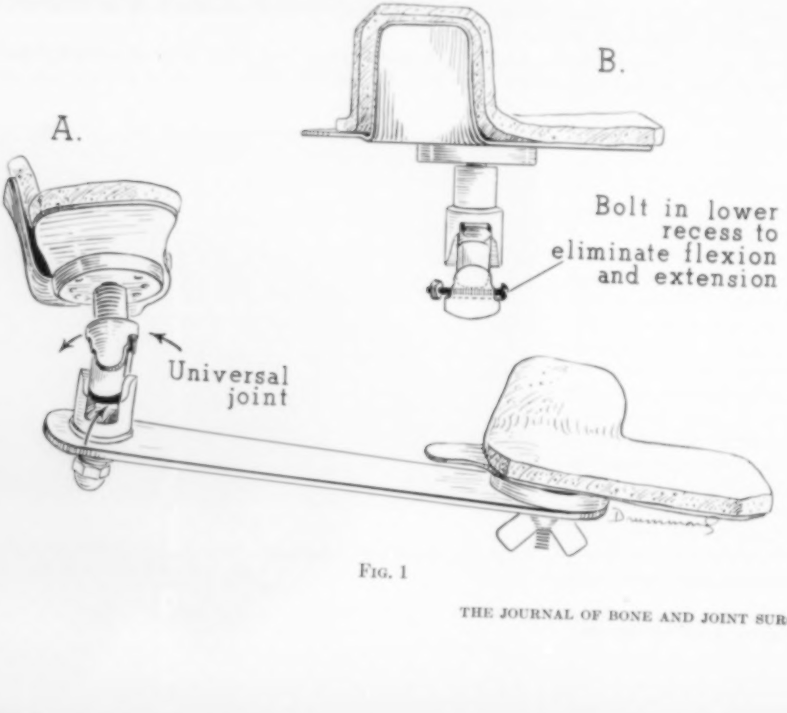

Fig. 1

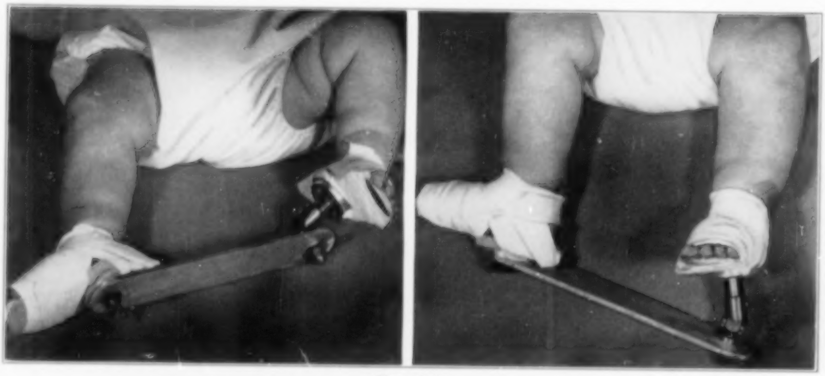

FIG. 2-A

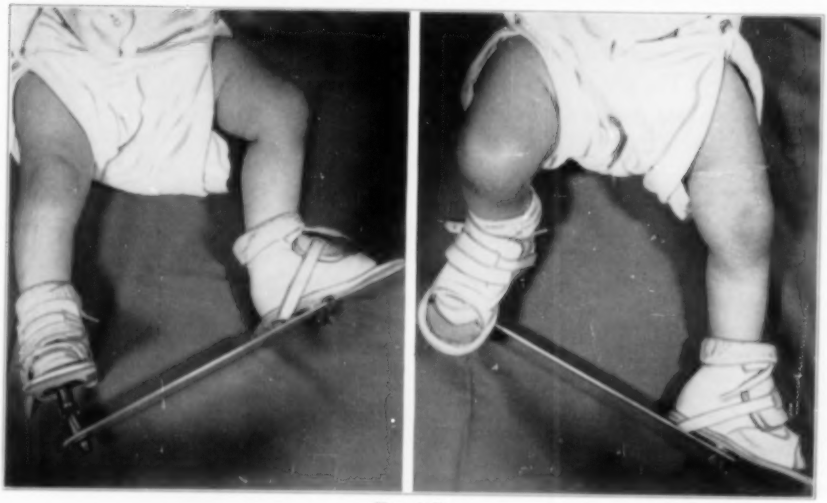

FIG. 2-B

If dorsiflexion and plantar flexion become undesirable, as has been the case in a few instances, a small bolt and nut is fastened through the recess of the joint, eliminating all motion in that plane.

NOTE: Thanks are due to Mr. Albert Foster, Manager of the Orthopaedic Department, Hospital for Sick Children, for his help and to Dr. Philip Ashmore, resident surgeon, for helpful criticisms.

# LASTING PLIERS

## A USEFUL PLASTER INSTRUMENT

BY WARREN G. KRAMER, M.D., AND WILLIAM A. CRAIG, M.D., LOS ANGELES, CALIFORNIA

*From the Orthopaedic Hospital, Los Angeles*

The sharp, rough edges of a plaster cast can be smoothly turned back with an inexpensive instrument which has been used at the Orthopaedic Hospital for many years. This consists of ordinary lasting pliers, which are obtainable at any cobbler's supply house as they are standard equipment for shoe work. The curved, serrated edges of the pliers, called "bulldogs" at this Hospital, are excellent for gripping the edges of a cast. At one end of the pliers is an angulated claw for removing nails; this can also be slipped under a cast and can be used to scrape rough spots.

The lasting pliers are also equipped with a removable hammer head, which is often useful in surgery. The pliers are excellent for exerting a strong grasp in the removal of wires, intramedullary nails, or other appliances.

The lasting pliers come in different sizes. No. 2 has been found to be optimum at this Hospital.

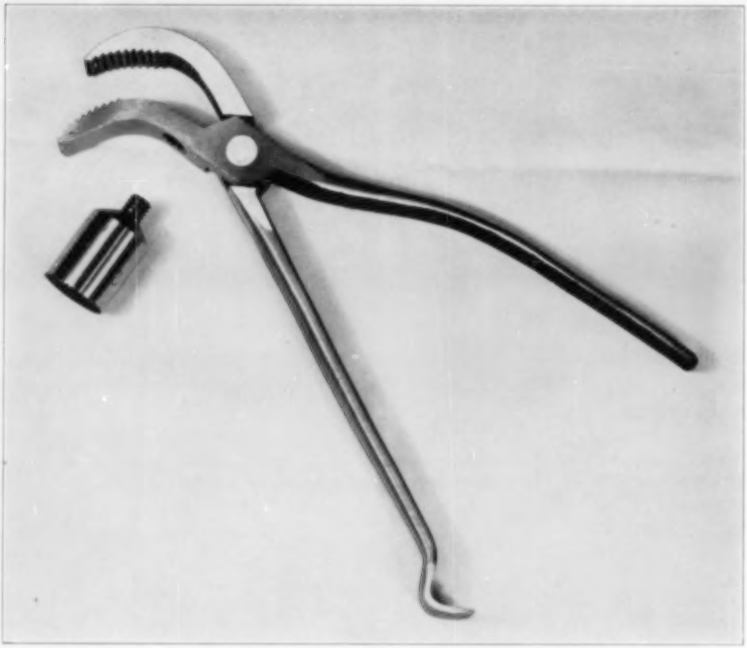

FIG. 1

# Proceedings

## THE JAPANESE SOCIETY OF ORTHOPAEDIC SURGERY*

The Twenty-seventh Annual Meeting of The Japanese Society of Orthopaedic Surgery was held at Tohoku University in Sendai on May 8, 9, and 10, 1954, under the Presidency of Dr. Saburo Iino. Summaries of the papers presented during the Scientific Sessions of this meeting follow. Dr. Shiro Mizumachi, Professor in the Orthopaedic-Surgical Department of Yokohama Medical College, was elected President for the year beginning April 1955.

### Presidential Address

*On the Methods and Results of Treatment of Congenital Dislocation of the Hip Joint in Japan.* Prof. Iino [1] collected and compiled essential data from all of the outstanding orthopaedic clinics in Japan, concerning 3,478 male patients (17.3 per cent.) and 16,576 female patients (82.7 per cent.) with congenital dislocation of the hip joint, 20,054 cases in all. The ratio of males to females is 1 to 4.8.

This total number represents 4.25 per cent. of all the cases examined in orthopaedic clinics. Under the impression that some local difference in this percentage might be found which would reflect differences in areas, races, cultural levels, climate, and diet, the author undertook to compare the percentages by regions and found that in the cold regions of Tohoku and Hokkaido, the percentage was higher than elsewhere. In Tohoku, in particular, it amounted to about 10 per cent. of the patients attending the orthopaedic clinics, a figure very much higher than that in other regions.

The relation between the age of the patient at the first examination and the period of time required for treatment was as had been anticipated. Patients less than six months of age recovered for the most part with treatment for about half a year, while those first treated at from one to three years of age required treatment for more than one year. This shows the importance of early detection and that treatment should begin within six months of the time of birth.

The progress following the institution of treatment was observed for more than one year in 6,466 cases. The results were as follows: excellent, 36.8 per cent.; good, 37.4 per cent.; satisfactory, 22.2 per cent.; and unsatisfactory, 3.5 per cent. The sum of the percentages of excellent and of good results is taken as the "cure coefficient" to express the results quantitatively.

Thus, the cure coefficient of the above statistics amounted to 74.2 per cent. and became 78.4 per cent. at the time of the last visit. Of the disturbances found to remain at the time of the last visit, acetabular dysplasia was most frequent, appearing in 20.4 per cent. Cases that did not recover beyond the state of subluxation accounted for 7.9 per cent., and reluxation occurred in 1.6 per cent. Such unsatisfactory results are no less frequent in cases in which the treatment was begun late. There was scarcely a case among those treated early which had to be operated upon.

When the methods of treatment are classified into methods for sucklings and for infants, the cure coefficient of the former, applied in treating subjects below one year of age, amounts to 90 per cent. and very few cases of disturbances are found to remain among them.

The methods for treating infants differ among the clinics. The author has selected two types for comparison of results. In the type A method, the plaster fixation is worn for two to four months followed by after-treatment; walking without plaster is allowed ten months after the initiation of treatment. In the type B method, the plaster fixation is continued for six to seven months, but free walking is allowed without reservation as soon as the splint is removed. The former method is employed by most orthopaedic surgeons but the results of treatment by the use of this method are inferior to the results obtained through method B, in which the patients are almost without treatment after the plaster bandage is once removed. There is a notable difference in the cure coefficient and such disturbances as avascular changes in the femoral head and acetabular dysplasia are also much more numerous in cases treated by method A.

If, however, the methods are analyzed from the standpoint of length of fixation, there is almost no difference in results, acetabular dysplasia tending to be more frequent when fixation was applied longer.

Classifying the results by the other important factor, the time at which these patients first stand and walk, the later the initiation of walking, the poorer the results, acetabular dysplasia becoming more frequent. This fact emphasizes the important part played by rational freedom of movement in expediting physiological cure of congenital dislocation of the hip joint.

On the question of whether the limbs should be continuously kept in frog-leg position, it may be pointed out that the results show little difference between the patients who have been kept in frog-leg position throughout the treatment and the patients in whom the limbs have been gradually extended during the fixation period.

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* Submitted for publication March 8, 1955.

[1] Sendai, Japan.

As to the merit of using anaesthesia at the time of reduction, it has been noted that under usual conditions of anaesthesia, cases of aseptic necrosis of the femoral head were found less frequently, an important point.

*A Histochemical Study of Skin Transplantation.* In order to study the tissue metabolism in the grafted skin and in the host, Dr. T. Morotomi [2], Dr. K. Chien [3], and Dr. T. Saito [4] observed, for a period, at the site of grafting the fluctuation of the content of acid saccharoprotein, of ribonucleic acid, of keratohyaline, and of elaidin, the vascularization in the grafted skin, and the granulation at the site of the grafting. In homogenous grafting, the nuclear figures are sometimes preserved under common staining, showing the spurious appearance of success, but histochemically little reaction was observed and the skin transplantation resulted in failure. In autotransplantation, however, vascularization begins in a few days at the recipient site, but this does not at once reach the grafted skin, which shows atrophy and degeneration with reduction in saccharoprotein and nucleic acid. In about a week after the operation, the newly formed vessels have approached close to the epidermis of the graft; the saccharoprotein content increases in the corium, the basal membrane, and the epidermis; the basal membrane becomes swollen. In ten days, the new vessels have reached the epidermis; the corium is replaced by granulation or connective tissue; the epidermis comes to have a regular arrangement of cells, the proliferation of which has declined.

The grafted skin should be small in size and have a thin corium for successful transplantation, a piece without the corium being apt to cause scars. When the transplanted piece is large and the corium is thick, many pores should be made in it by pricking with needles from the corium side. This will cause a tendency to expedite the early circulation of humor, to shorten the degenerative stage, and to induce early proliferation of the epidermis. The authors have obtained satisfactory results in the clinical application of the method.

*The Influence of Enzymes on Wound Healing.* Dr. Kashiwagi [5] and Dr. Y. Okada [6] pointed out that the actions of varidase, trypsin, and hyaluronidase are different in their mechanism, but that all are specific in that they digest and decompose necrotic tissues without acting upon viable cells. They had observed the effects of enzymes upon wounds, especially on long-standing infected wounds. A bacteriological examination of the infected wounds showed that most of the infecting bacteria were staphylococci.

An *in vitro* experiment was also performed, comparing the digestive actions and their temporary changes of (1) trypsin, (2) trypsin and hyaluronidase, (3) varidase, and (4) varidase and hyaluronidase, and (5) controls of fibrin obtained from goat's blood. The digestive action was most intense with trypsin and hyaluronidase; the action of trypsin and varidase was strongest in the first thirty minutes, in which the greatest part of the fibrin was digested, gradually lessening thereafter and losing nearly all its efficacy in three hours.

Crush wounds were made on the dorsal skin of dogs and trypsin was applied to some of them. Upon macroscopic and microscopic examinations of the trypsin-treated and control cases, the former showed clean pink wounds free of scabs and blood clots, five hours after the experiments had been begun, while in the controls, marked cell infiltration and necrotic tissue and scabs were observed.

The changes in the tissues before and after the application of varidase and trypsin were observed in clinical cases. In general, the wounded tissues quickly showed an oedematous condition in the connective tissue, marked leukocytic infiltration, and very weak vascularization. Before the application of these enzymes, the presence of bacteria was shown, but after the treatment leukocytic infiltration decreased, round cells and fibroblasts increased, blood capillaries were found in large numbers, and no bacteria were detected, thus showing a frank tendency to healing.

These enzymes are said to have generalized side-effects when applied in the thoracic cavity, but no side-effect was observed following application to external wounds.

*Studies on the Influence of Local Stimulation on the Longitudinal Growth of Bones.* Dr. K. Oyoshi [7] had divided the tibial diaphyses of young rabbits transversely into three portions, each of which was wounded or into each of which a Kirschner wire, an ivory rod, or an arginic acid rod was inserted. The influence exerted by such external stimuli on the longitudinal growth of bones had been studied macroscopically, roentgenographically, and histologically.

There seemed to be a significant stimulation of growth as compared with the control animals.

*The Influence of Shortening of the Femur and of Sciatic Neurectomy on the Growth of Bones.* Dr. H. Katsu [8] produced femoral shortening experimentally in young rabbits by excising one-eighth of the bone on one side and fixing it by means of an intramedullary pin. He had then observed the growth of the femur and tibia at weekly intervals, using roentgenographic measurement and measuring the distance between lead lines produced at the proximal and the distal metaphyses by the precipitation of a lead acetate solution injected intravenously. The lines were very clearly visible. (Okada and Mimura: *Nippon Kōkbūyō Gakkai Zasshi* (Jap.), **11**: 365, 1930.) As controls, rabbits were used with one femur fractured transversely and others with one femur shortened and the other femur fractured transversely. In the cases with shortened femora and with fractured femora, no difference was observed in the growth of the bones of the limb in comparison with the normal side, but a slight acceleration of growth was seen in the upper and lower ends of the affected femora. When one of the femora was shortened and the other fractured, no difference was observed. Following sectioning of the sciatic nerve on one side, an accentuated growth was observed in the tibia but not in the femur. The better growth of the limb is probably due to the increase of blood flow in the arteries of the limbs operated upon and the dilatation of the small arteries caused by ulcers on the soles.

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[2] Hirosaki, Japan.
[3] Hirosaki, Japan.
[4] Hirosaki, Japan.
[5] Tottori, Japan.
[6] Tottori, Japan.
[7] Sapporo, Japan.
[8] Tokyo, Japan.

*Bone Changes in White Mice Fed High Fat-Casein Diets and Made Diabetic with Xanthurenic Acid.* Dr. M. Harada [9], Dr. T. Oyama [10], Dr. T. Hoshino [11], and Dr. M. Nishi [12] had fed white mice a 35 per cent. fat-casein diet; the mice had been made to show the symptoms of so-called xanthurenic-acid diabetes. The changes caused in their bones were observed histologically, histochemically, and biochemically. In body weight, they showed little difference from the control mice, but the experimental animals suffered marked depilation. There was no significant change in nitrogen metabolism but the acetone compounds in the urine and the serum alkaline phosphatase were increased.

The epiphyseal plates were thinned and the spicules of the cartilagenous matrix were shortened and decreased in number. In the joint cartilages, degeneration progressed widely and metachromasia gradually declined and finally disappeared. These bone changes became more notable as the diabetic symptoms advanced, and in consideration of the increased acetone compounds in urine, these changes are seemingly due to an intoxication by the latter.

*Experimental Studies in Acute Bone Atrophy.* Dr. T. Makiyama [13], Dr. H. Wakayama [14], and Dr. M. Kukida [15] reported their investigation into the nature of non-inflammatory acute bone atrophy. The following fundamental experiments were carried out on guinea pigs weighing about 350 grams. In one group of the animals, one of the hind limbs was fixed to the abdominal wall with adhesive plaster or plaster-of-Paris; in another group, the veins of one of the hind limbs were ligated so as to induce blood stasis; in a third group, a section of the sciatic nerve on one side was excised; in a fourth group, the tibia on one side was fractured subcutaneously and left without fixation; in a fifth group, one knee joint was contused with a rubber hammer, care being taken not to cause fracture. The changes in the femora and tibiae were then observed. In all of the groups, more or less extensive bone atrophy was observed. On roentgenographic examination, the bone atrophy was severest in the first, second, and fourth groups. In the third group, atrophy progressed with time, reaching maximum severity during the fifth week, while in group five only a very slight atrophy was observed in the first and the second weeks. In the roentgenograms showing bone atrophy, there were always rarefaction of the cortices, disturbed trabeculation, and blurring of the outlines, but the characteristic figure of patchy rarefaction was hardly discernible.

Histologically, the bones showed halisteresis in general; osteoclasts appeared in the second week, becoming most conspicuous in the third week; there were signs of recovery in the fifth week in the first, second, fourth, and fifth groups, while in the third group no sign of recovery had appeared in the fifth week. The atrophy was most conspicuous at the epiphyses of the injured bones in the fourth group and in the same parts in the third, second, first, and fifth groups, in the order named. It is clear that the atrophy in all of the pigs was caused by a dystrophy of tissues resulting from disturbed blood circulation, but since a mere stasis is sufficient to induce bone atrophy, the presence of harmful chemical compounds or of a disturbance of metabolism may be regarded as the ulterior cause.

*Influences of Various Antibiotics and Hormones on the Mechanism of Repair of Injured Bones.* Dr. K. Mikamo [16] had studied these influences using the tibia and radius of rabbits. Penicillin was found to have some effect in inhibiting bone formation, but aureomycin, terramycin, and chloromycetin did not produce such an effect. Bicillin has an inhibiting effect like penicillin. The anti-osteogenic effect of penicillin may be inhibited by an appropriate dose of parotin (a hormone of the salivary gland), which seems to act through the medium of the hypophysial-adrenocortical system. In the same way, cortisone and streptomycin used in sufficient doses are also effective in overcoming such an inhibitory effect of penicillin.

Large doses of parotin, the administration of bovine hypophysis, of cortisone and the powder of the thyroid gland strongly inhibit the formation of bone.

Purified vaccine, methylandrosterone, the sexual hormones, chondroitin-sulphuric acid, and Kallikrein exert no perceptible influence on the repair of bones in young rabbits.

Vitamin K visibly expedites the repair of bone.

*Serological Studies on Fracture Healing. The Production of Auto-Antibodies by Bone Elements Entering the Blood Stream, Following Experimental Fractures.* It has been recognized that in some instances, as when certain cells are destroyed, the destroyed cells give rise to antigen, which induces a cell toxin that acts as an antibody to this antigen. For example, in animal experiments on traumatic shock, it has been proved that following the passage of myoglobin into serum and its excretion in the urine, antibodies against such myoglobin are detected, and this antigen-antibody reaction is the causative factor of shock. Impressed by these considerations, Dr. M. Kondo [17] used a bone extract made from bones freed of soft tissues, and freed of blood by washing several times. The washed bone was immersed in hydrochloric acid, washed with water, and extracted in distilled heated water. This extract, upon being injected into rabbits, produced antiserum of the high precipitin value of 200 × with a precipitin content of 16, and a by-reaction of 200 × 1 to dog serum. For demonstration of bone elements in blood, this antiserum was used in double dilution.

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[9] Wakayama, Japan.
[10] Wakayama, Japan.
[11] Wakayama, Japan.
[12] Wakayama, Japan.
[13] Nagoya, Japan.
[14] Nagoya, Japan.
[15] Nagoya, Japan.
[16] Hamamatsu, Japan.

Complete fractures were caused experimentally in healthy adult dogs, the edges of the fractured bones being crushed with a Luer gouge. After the operation no change was noted in the general condition of the dogs, but the protein reaction in urine became positive in a short period of time in most of the cases.

The urine was used as an antigen solution, and the precipitation in antiserum was tested. The reaction became positive in three to six hours, that is, bone elements were being excreted in the urine. This reaction was most conspicuous in three to six hours, decreasing gradually thereafter, but was still demonstrable one week after the operation.

The production of antibodies to all the various bone elements was demonstrated to begin in two to seven days, to continue for five to seven days, and then to be discontinued. The appearance of auto-antibodies begins approximately at the time of disappearance of the antigen above, or somewhat later.

*The Metabolism of Nucleic Acid in Callus Formation.* The process of fracture healing is accomplished by the combined action of organic ground substances and of inorganic materials. The metabolism of nucleic acid, which is assumed to be significant in protein anabolism, at the time callus is formed, is not, however, clearly understood. For the purpose of elucidating the question, Dr. K. Ito [18] and Dr. H. Ishigami [19] investigated (1) the change in the content of nucleic acid of acid-soluble phosphorus, of lipoid phosphorus, and other phosphorus compounds, at the time of callus formation. They also studied (2) these changes in comparison with the phosphorus fraction in the liver and (3) the relation of nucleic acid to the metabolism of inorganic elements (calcium and phosphorus) in blood and in bones.

For the experiments, mice of twenty to twenty-five grams of body-weight were used. Their femora were subcutaneously fractured, and two, four, eight, sixteen, twenty, and twenty-five days thereafter, some of them were injected with 0.3 microcuries of $P^{32}$ or $Ca^{45}$ per gram of body-weight and sacrificed three hours afterward. Then, the radio-activity and the contents of phosphorus and calcium in the whole blood, in the bones, and in the liver were quantitatively determined, and the specific activity and the relative specific activity of the various samples were measured. During the process of fracture healing, the metabolism of nucleic acid reaches the maximum about the eighth day after the fracture, and it is deduced that the protein anabolism specific to bones is effected within this period. The acid-soluble phosphorus as well as the other inorganic elements are observed to be active in the first stage; then calcium phosphate is precipitated on a matrix of protein and a reshuffling goes on in the disposition of protein substances. The daily increase of the relative specific activity of $Ca^{45}$ shows the increase of such precipitation. The specific activity of $Ca^{45}$ in blood continues to fall. The inability of tracing the course of $P^{32}$ is perhaps due to the wideness of the scope of activity of inorganic phosphorus. The metabolism of lipoid phosphorus in bones was found to rise, and it may be pointed out with interest that Follis (Follis, Jr., Richard H., and Berthrong, Morgan: Histochemical Studies of Cartilage and Bone. I. The Normal Pattern. *Johns Hopkins Hospital Bull.*, **85:** 281-296, 1949.) has presumed that esters of phosphoric acid originate in lecithin. The accentuation of metabolism of nucleic acid, as well as lipoid phosphorus and acid-soluble phosphorus in the liver, and the increase of turnover of such substances in the bones of the unaffected side show that the healing process of fractured bones is not a local process, but is related to the metabolism of the entire skeleton and of the whole body.

*Dynamic Callus and Electric Callus.* Recently, Küntscher and his co-workers have postulated that calluses are formed by mechanical, thermal, and chemical stimuli without premising the existence of a fracture. They have called such a callus a "callus without fracture". Dr. I. Yasuda [20], Dr. K. Noguchi [21], and Dr. T. Sata [22] have investigated this proposition by means of the following experiments. Two rods of plastic were passed through the femur and joined by a spring to exert compression on the bone. The results showed that, when compression is directed parallel to the bone axis, osseous callus in the form of a low ridge was formed in the periosteum and the endosteum between the rods, and when the compression acted at right angles to the long axis of the bone, a crescent-shaped callus was formed in the endosteum and a callus in the shape of a right-angle triangle in the periosteum. The above is probably the result of an expedited metabolism in the part of the bone to which the dynamic energy was applied. Since electricity is always generated at parts of living organisms which are active, greater potentials may also be expected in the callus. Upon measuring the electric potentials of the compressed parts of long bones, it was found that these parts showed

[17] Tokyo, Japan.
[18] Tokyo, Japan.
[19] Tokyo, Japan.
[20] Kyoto, Japan.
[21] Kyoto, Japan.
[22] Kyoto, Japan.

negative potentials and the parts under tension showed positive potentials. This shows that in the formation of callus, dynamic energy is transformed into electrical energy, and suggests the possibility of forming callus merely by electrical energy. Using a battery of 1.5 volt cells, the authors kept a current of one micro-ampere passing through the femur for three consecutive weeks; a ridge of callus formed, running through the periosteum from pole to pole. The cathode side had more callus than the anode side. When the current was between one and 100 micro-amperes, bony callus was formed, but when the current was stronger than 100 micro-amperes, cartilaginous callus also appeared. When the current was raised to more than one milli-ampere, bone destruction took place.

From this experience, the authors concluded that the dynamic energy exerted upon bones is transformed into electrical energy, and the latter plays an important part in callus formation.

*A Study of the Calcium Metabolism of Bone Transplants with the Aid of Radio-Active Calcium.* DR. H. AZUMA[23], DR. Y. IWASA[24], DR. R. OKAMOTO[25], DR. S. NISHIMURA[26], DR. O. KUBOTA[27], and DR. A. HAYASHI[28] presented their observations on the absorption of $Ca^{45}$ by various methods while studying the problem of the viability of bone grafts.

Pieces of iliac bone were used for cancellous grafts, pieces of tibia for cortical grafts and pieces of rib for grafts of an intermediate type between the other two types. These grafts were transplanted subcutaneously into animals of the same species and the absorption of $Ca^{45}$ in them was noted. The results showed that absorption by the iliac grafts was the greatest, followed by that of the rib and of the tibia, in that order.

Considering the size of the bone grafts, the smaller the size, the greater the proportion of $Ca^{45}$ absorbed

When the deep surface of the transplant contained bone marrow, the graft absorbed more $Ca^{45}$ than when there was no bone marrow, but no marked difference was observed between grafts having periosteum on the deep surface and those without. When the transplanted bone had neither bone marrow nor periosteum, the $Ca^{45}$ absorption was the greatest.

When fresh autografts, boiled autografts, homogenous cold-preserved grafts, and homogenous frozen grafts were compared, the $Ca^{45}$ absorption was the largest in the fresh autografts and was somewhat larger in the cold-preserved grafts than in the frozen samples.

*Comparison of Results of Bone-Grafting in Various Paralytic Cases.* That healing following bone-grafting in cases of paralysis due to spinal-cord injury is much slower and more protracted than in infantile paralysis has been pointed out by Prof. Iwahara and others (Iwahara, T., and Ikeda, K.: *Shujutsu* (Jap.), **6**: 21, 1952). In the cases of other spinal diseases and also in those of peripheral-nerve palsy, bone transplantation is often undertaken. In order to investigate the clinical progress in such cases, DR. H. MATSUO[29] had experimented with four groups of animals: (1) those with injured spinal cords, (2) those with damaged anterior horn cells, (3) those with divided anterior roots, and (4) those with divided sciatic nerves. The following results were obtained.

Bony union of the grafted bone was always observable within fifteen days after grafting, although the degree varied by groups. In the groups with damaged anterior horn cells and with divided anterior roots, the formation of new trabeculae was active to a degree not to be seen in the two other groups, in which the showing nearly equalled the normal. In the group with damaged anterior horn cells, substitution was accomplished within sixty days in all of the animals. The rate of union of the transplanted bone was lower in the following order of Group 2, Group 3, and Group 4, and was lowest in Group 1.

The better fusion of grafts in Group 2 and Group 3 reveals that the parasympathetic nerves play a promoting role in the mechanism of bone proliferation. In these two groups, secondary effects of muscle paralysis are the symptoms which are mainly observed, the autonomic influence being slight. In the group with divided anterior roots, some lowering of the function of the sympathetic system may be expected, but such a lowering may be deemed to be amply compensated by the sympathetic control through branches running in all directions through the sympathetic trunk. In the group with injured spinal cords, all of the nerves including the motor, the sensory, and the vegetative nerves were cut off, the parasympathetic being particularly affected, so that in this group the fusion of the bone grafts becomes the most unsatisfactory.

*A Dynamic Study of Various Methods of Fracture Treatment and Arthroplasty.* Cadaver experiments by DR. IWAO YASUDA[30], DR. KWAN OKADA[31], DR. TSUNEYUKI KATO[32], and DR. TETSUO SATA[33] of the results of treatment applied to fractures of the shaft and the neck of the femur in which an electromagnetic pick-up is used showed that, in the former cases, the method of intramedullary fixation brings about a distribution of energy similar to that in normal bones. They also found that of the various sizes of Küntscher intramedullary nails, the medium-sized nail is best adapted to restore a nearly normal state. The large-sized nail results in too firm a fixation of the fractured part, which thus receives only a very limited amount of energy, a fact in conformity with the small amount of callus formation previously reported by the authors.

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The Eggers internal sliding plates are also adapted to create energy distribution similar to that of normal bones.

In Pauwels' second degree of fracture of the femoral neck, the use of the Smith-Petersen three-flanged nail will cause a decrease of the energy to one-half of the normal amount directed to the fractured part, but if Küntscher's so-called "steile Lage" (steep direction) is used, the normal dynamic relation is restored.

In the case of Pauwels' third degree of fracture, an application of the "steile Lage" will cause recovery of normal dynamic state and no subsequent Pauwels' "Umlagerung" osteotomy is necessary, proving that Küntscher's completely automatic intramedullary nail is the best-adapted appliance.

In applying hip prostheses, the authors found that it is imperative to drive a Judet type prosthesis in a manner similar to a "steile Lage"; and when a Thomson "light-bulb" type or an Eicher-type prosthesis is used, the edge of the femoral neck should be cut at an angle of about 30 degrees; such a precaution will dispense with the fear of rotation of the prosthesis. It is of advantage to apply a Thomson-type of prosthesis as a "steile Lage" would be applied.

*The Fixation of Fractures with the Eggers Plate.* **Dr. Takao Miyamoto**[34], **Dr. Iwao Hirotani**[35], and **Dr. Seiichi Ohmura**[36] have used the Eggers plate with good results. The number of fractures treated was ninety-one in eighty-six patients; among these the fresh fractures numbered sixty-three and the number of cases of non-union that were treated was twenty-eight. The results proved satisfactory in almost all cases.

There were twelve fractures near joints to which the Eggers plates were bent to fit and applied for assuring early joint motion; in eight of these the plates were applied as blade plates following subtrochanteric osteotomy, pertrochanteric fracture, fracture at the distal end of the femur, and fracture at both ends of the tibia. There were twelve cases of non-union in which two plates were used in two different directions.

These plates may be used with very good results in operations for non-union and for latent infection, as well as following subtrochanteric osteotomy.

*Fundamental Studies on the Use of Titanium in Orthopaedic Surgery.* **Dr. W. Wakamatsu**[37] had inserted pure titanium plates in saw cuts made in the tibia and had measured the force required for extracting them at the end of the fourth, the sixth, and the twelfth week, and at the end of the sixth month. For comparison, plates of 22A and 18–8 steel and of iron were applied in the same manner. The force required was least with iron, remaining at 7.5 grams per square millimeter in the twelfth week; but with titanium, this value was the highest, 22A and 18–8 steel being between the two. Before the eighth week, no great difference is shown in the extraction force necessary with the titanium and the steel plates, but in the twelfth week, the difference between titanium and the other metals rose to 7.5 to 8.5 grams per square millimeter, and at six months that between titanium and 22A rose to about 10, and rose to about 15 grams per square millimeter between titanium and 18–8 steel. With titanium plates, the values in every week for individual cases are comparatively uniform, but when 18–8 steel plates are used, the values are unstable. With 22A plates, the values are not so unstable but much more fluctuating than with titanium plates.

Upon histological examination of the tissues about the plates, the appearance in the case of titanium plates is that of negligible reaction, new formation of trabeculae being expedited about the plates; but when other plates are used, the reaction is variable from case to case and of a high individual dissimilarity.

Hardly any new trabecular formation and marked bone necrosis were observed about the plates when iron was used. This is perhaps caused by the strength of the electric current generated when iron is inserted into living tissue. Experiments by the author to observe the effects of electric currents on the tissues have led to the conclusion that when the current is too large, the action is destructive of bone, as in the case of iron plates. When the current is a little weaker, the reaction is highly variable, as when 22A or 18–8 steel plates have been used. When the current is still weaker, the reaction is one of stimulation of bone tissue, as observed in the case of titanium plates.

*Results of Treatment at Kyushu University of Delayed Union and Non-Union of Long-Bone Diaphyses.* **Dr. Tamikazu Amako**[38] and **Dr. Kenichiro Goto**[39] reported that between 1926 and 1953, 296 such cases were treated at Kyushu University Hospital. The majority of the patients were from twenty to thirty years of age and the number of cases in the upper and in the lower extremities was approximately the same.

In this period of twenty-eight years, treatment was by freshening of the fractured bone-ends and application of beef-bone grafts up to 1938, by bone transplants since about 1931, and by intramedullary fixation with Küntscher nails since 1948. For bone-grafting, cancellous bone grafts from the iliac crest have been preferred to tibial grafts in most cases. *Os germinativum* made good apposition but was not sufficiently firm for fixation.

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In general, the success or failure of the treatment of non-union by bone-grafting depends on the firmness of fixation. For fixation we may not always depend on plaster alone. The intramedullary nailing is best in effecting firm fixation, so that it was applied in fourteen cases without grafts and in twenty-seven cases with bone transplantation. There resulted only one case of failure at this University.

The Eggers contact splint may be used with advantage in cases of fresh fractures, but in cases of non-union, they are apt to break down.

For delayed union, drilling of bone was found to give unexpectedly good results in twenty-nine cases (89.65 per cent.).

Two patients had sympathetic neurectomy and showed good results.

The majority of the above cases were cured by one operation. However, forty-four cases required two, twenty-five required three, and eight required four operations, and 7.8 per cent. of the cases among the total failed to unite.

*Operative Treatment of Old Dislocation of the Shoulder, the Elbow, and the Hip Joint.* DR. ATSUTO NISHIO[40], DR. MAKOTO YAMAMOTO[41], DR. TOMOMASA ITO[42], and DR. KAZUO SUGINO[43] had performed operative reduction in twenty-seven cases of dislocation of the shoulder, in eighty cases of dislocation of the elbow, and in fifty-two cases of dislocation of the hip joint at Kyushu University Hospital.

The majority of the patients with shoulder and hip dislocations were between twenty and forty years of age, and those with dislocation of the elbow were mostly teen-agers.

The time which had elapsed since the date of luxation to the treatment was one to six months in the majority of cases, but thirty-seven cases (23 per cent.) were of more than six months' duration, the oldest exceeding ten years.

Many had complicating fractures; there were sixteen cases (59 per cent.) in which fracture of the greater tuberosity complicated the shoulder dislocations.

Failure of reduction occurred in one case of dislocated shoulder and in two cases of hip dislocation. In six cases each of shoulder and of hip dislocation, arthroplasty was performed because of contracture of the soft parts.

Traction before operation upon the hip joint was indispensable in every case.

Redislocation of the shoulder occurred in one case and of the hip in two cases.

Study of end results showed that, after reduction in seventeen cases of shoulder dislocation, six patients were able to raise their arms more than 110 degrees, three up to 90 degrees, and seven between 60 and 80 degrees. Of twenty-six patients with dislocation of the elbow, ten could bend their elbows more than 100 degrees after reduction, ten over 80 degrees, but in the other cases, mobility was less than 50 degrees. Of the patients treated for luxation of the hip, four reported recovery of normal function, five of moderate limitation of mobility with ability to walk over five miles, three with ability to walk more than two and a half miles, but three had severe contractures, pain, and a limp.

*Studies of the Supporting Tissues by Means of Tissue Culture.* DR. M. NAKAGAWA[44] and DR. K. TATEIWA[45] have reported their investigations in this field as follows: 1. Since Fell (Fell, H. B., and Robison, R.: Growth Development and Phosphate Activity of Embryonic Avian Femora and Limb-Buds Cultivated in Vitro. *Biochem. J.*, **23**: 767–784, 1929.) cultivated femoral tissue of the chick embryo, many experiments have been performed by his double-cover method (D.C.M.); however, this method requires a complicated technique and tedious procedures; the proportion of successful results is low. Considering such disadvantages, Dr. M. Nakagawa and Dr. K. Tateiwa have employed a roller-tube method (R.T.M.) with much better results.

a. *Curves of bone growth and growth rates.* The growth curves of femora and tibiae of embryonic chicks of six and a half days cultivated by the D.C.M. and by the R.T.M., on the average, when several subjects are used, form smooth curves represented by the equation: $y(t) = L(1-e^{-rt})$ in which $y$ stands for the increment of the length of the bone, $L$ for the highest limit of $y$, $e$ for the base of the natural logarithm, $r$ for a constant related with the speed of growth, and $t$ for time. The growth rates in individual subjects, however, do not always follow such curves. Because of this, the authors have adopted the method of calculating the growth rates of individual bones by means of a multi-term equation and compare their $b = \frac{\Sigma xy}{\Sigma x^2}$ in which $x$ stands for time and $y$ for the measured length of the bone. By such means and a comparative calculation by means of binary coordination, the superiority of R.T.M. over D.C.M. with respect to growth rate is clearly demonstrated.

b. *The influence of pH on the growth rate of bone* $(b = \frac{\Sigma xy}{\Sigma x^2})$. For testing the pH, a Beckmann's G-type pH-meter was used. The results obtained when seven-, eight-, and nine-day chick foetuses were cultivated for six days showed that the rates fell in a normal distribution with the peak at pH 7.5. No significant difference was noted between pH 7.25 and pH 7.5, or at pH 8.0 and over; at pH 7.0 or a lower value it fell below that at pH's between 7.25 and 7.5.

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A test of growth rate and calcification at pH 7.0, pH 7.4, pH 7.8, and pH 9.0 with femora of seven-day chick foetuses showed that there was no significant difference when the pH value was between 7.0 and 7.8 and that the ossification progressed most favorably at pH 7.8. For measuring the rate of ossification, Kossa's silver-nitrate method was used.

c. *The influence of the quantity of the cultivating solution on the growth rate of bone.* Cultivated at pH 7.6 to pH 7.8, the use of two cubic centimeters of nutritive solution proved better than the use of one cubic centimeter of it, the risk being less than one per cent.

d. *Influence of feeding on the growth of bone.* At pH 7.6 to pH 7.8, one group of the cultures was fed new nutritive solution every second day and another every third day, but no significant difference on growth was found in the two groups.

2. *Effect of ACTH, hydrocortisone, and desoxycorticosterone acetate on fibroblasts, bone, and cartilage.* ACTH has no effect on such tissues. Hydrocortisone inhibits the growth in high concentration and depresses it in low concentration. Desoxycorticosterone also suppresses the growth of the cultivated tissues, but not so much as does hydrocortisone.

Histological examination showed that the fibroblasts in the cultivated tissues showed no change from their state in the control under the influence of ACTH, but under hydrocortisone all of the cells became undersized and loosely scattered; however, under the action of desoxycorticosterone, the cells were densely congested, and the cell bodies and their interstices filled up with oil-like droplets.

The collagenous fibers retained their status in the control under the effect of ACTH and hydrocortisone, but when treated with desoxycorticosterone, they were negative under azan, Mallory, and van Gieson staining.

No histological change was seen in bone or cartilage.

*A Study of Transplantation of Freeze-Dried Homogenous Nerves.* The sciatic, tibial, fibular, and axillary nerves taken from rabbits were used in this study by DR. B. KAWAMURA[46], Dr. T. UTSUMI[47], and DR. M. OHGA[48]. To freeze the nerves, sections were placed alongside slender bamboo sticks to prevent bending; they were hermetically sealed in aseptic glass tubes, and were refrigerated in a dry ice-ether cold box at −80 degrees centigrade. Even the sciatic nerves take only a few seconds for freezing, when removed from rabbits. When vacuum-dried at pressures of $10^{-3}$ to $10^{-4}$ the sciatic nerves lose 65.7 percent. of their total water content in three hours, a percentage approximating the total free-water content of the nerves. The specimens of nerves used by the authors were prepared by this method without exception. The freeze-dried nerves were somewhat more translucent and were lower in pliability, ductility, and tenacity than fresh nerves. For transplantation, the dried nerves must first be made to absorb water to recover their physiological state. They recover their original weight, color, and pliability in about two hours when immersed in physiological saline or homogenous serum. Their ductility and tenacity, however, will remain at the level of dried tissues, not regaining the original level of fresh nerves. Upon comparing the results of immersion in physiological saline and in serum, the water absorption is similar, but some difference is found from the viewpoint of histology, and serum immersion seems to be more desirable.

Upon examining the ultrafibrils under the electron microscope, no great difference was found between fresh specimens and dried nerve fibrils immersed for two hours either in serum or physiological saline, except that in the latter, some of the specimens showed differences in the cycle of the banded structure. The authors have reserved their judgment as to whether such a difference indicates a figure of degeneration.

Pieces of freeze-dried sciatic nerve of rabbits were immersed in homogenous serum for two hours and were transplanted to the defect made by cutting out about 1 centimeter of the tibial nerve in homogenous bridging. On the first day after the transplantation and thereafter at varying intervals up to twelve weeks, the transplanted part including the proximal and distal ends of the cut nerve of the different rabbits were excised together with the gastrocnemius and were examined histologically. It was found that after the lapse of two weeks, the connective tissue at the ends of the transplanted pieces had healed and the fusiform connective tissue around it was beginning to be repaired. The proximal end of the transplanted nerve began to show retrograde degeneration in twenty-four hours and, from the second week, budding and growth of new axons and myelin sheaths were observed progressing through the interspaces of the degenerated old myelin sheaths. During the third to the fifth week, these newly grown fibers vigorously invaded the transplanted pieces and in the seventh week ran beyond the distal joint into the distal section. The transplanted piece showed marked degeneration from the second week and the degenerated matter was disposed of by the fifth to the seventh week. Throughout this period, the Schwann's cells remained lined up in perfect order. They kept distinct from the surrounding connective tissue and gave passage to the new nerve fibers, which made these cells appear to be guarding the way and guiding the regenerated nerve.

Lastly, the distal section of the cut nerve was noted to have degenerated in compliance with Waller's law; this was noted in the second week. There was marked atrophy in the muscle group supplied by the cut nerve during that week.

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Electromyographically, no functional regeneration has been demonstrated to date, although twelve weeks have elapsed since the operation.

*A Clinical Study of Lumbar Anaesthesia.* Dr. T. Kitahara[49], Dr. S. Kunori[50], Dr. N. Miura[51], Dr. J. Yoshida[52], Dr. T. Matsubara[53], Dr. S. Yamashiro[54], and Dr. Nomura[55] reported their study of the problems concerned with lumbar anaesthesia through tracing the diffusion of an injected fluid clinically and externally with the aid of radio-active isotopes. If 40 to 50 microcuries of $I^{131}$ is added to the fluid to be injected, the diffusion of the fluid may be traced by the radiation of gamma-rays, and even quantitative distribution may be measured with a Geiger counter. As the quantity of the added $I^{131}$ is very small, no complications from this isotope are to be feared, and since the anaesthetic effect is not interfered with, the method has the advantage of making possible at the same time minute observations on the narcosis produced.

When 1.0 to 2.0 cubic centimeters of isotonic solution are injected, most of it remains accumulated at the site of the injection, regardless of the body position; diffusion may take place to the extent of 15 centimeters cranially and 5 centimeters caudally and no change is shown with the lapse of time. Among the different techniques of infusion, mixing with a large quantity of spinal fluid by repeatedly using suction and infusion had some effect in extending the diffusion, but rapid infusion and preliminary discharge of spinal fluid were demonstrated to be of no value. When isotonic solution is to be used, there is no dependable means but to select the region for infusion which is most appropriate for the operation as planned.

When a mixture of P-Amino-benzoyl-dibutylaminopropanol and 2-Butyloxychinolin-4-carbonylacid-diethylenamide-hydrochloride and 20 per cent. glucose solution in equal parts, a high-density solution, is injected with the patient in a horizontal lateral position and the subject is then laid in a supine position, the solution will run cranially and caudally under the influence of the physiologic curvature of the spine, leaving rather a minor portion at the site of injection and forming two peaks at a higher and a lower level. The part diffusing cranially will go steadily higher and higher with time, but if a pillow is placed under the head, there is no fear of its reaching above the cervical spine. On the other hand, the part which diffuses caudally shows little change with the lapse of time and is of little consequence in most cases. In extreme cases, all the infused drug runs into the caudal part *en bloc*, and the anaesthesia comes to be limited to the anal and the perineal regions.

The authors' method has revealed that all cases of unsuccessful lumbar anaesthesia were occasioned when the injected drug failed to attain a certain concentration at the roots of the appropriate spinal nerve. It must be borne in mind that in utilizing high-density solutions that fluid at the second and the third lumbar segments occupies the highest level and care should be taken to concentrate the entire dose of the injection more to the cranial or the caudal site thereof, according to the area to be operated upon.

The P-Amino-benzoyl-dibutylaminopropanol and 2-Butyloxychinolin-4-carbonylacid-diethylenamide-hydrochloride with saline solution of a lower specific gravity, is a widely used low-density solution. Although advertised as having a lower specific gravity than spinal fluid, it is only very slightly lighter, and at certain temperatures it is even heavier. The experiments by the authors have proved that it is in no way different from the isotonic solution in its behavior.

It must be noted that if the patient takes the sitting position for the injection and then the supine position, there is danger of the drug running cranially to a marked degree, and an unexpectedly high level of anaesthesia results. Therefore, it is desirable that the injection be made with the patient in a lateral-lying position whenever possible. The authors also recommend the abandoning of such undependable low-density anaesthetics as P-Amino-benzoyl-dibutylaminopropanol and 2-Butyloxychinolin-4-carbonylacid-diethylenamide-hydrochloride and, instead, the use of the two kinds of isotonic and high-density drugs in surgery.

*A Study of Spinal-Cord Injuries, with Special Reference to Paralyzed Bladder.* Dr. T. Otani[56], Dr. T. Imoto[57], Dr. A. Kajiwara[58], and Dr. T. Fujishita[59] reported their experience in treating thirty-seven patients with spinal-cord injuries and thirty-one more patients with paralyzed bladders due to other causes. They had made it a practice, in treating spinal-cord injuries to resort to early operation. The paralyzed bladder, however, they felt, was not much improved by operation, and a series of anti-paralytic measures seemed necessary instead in such cases. Improvements were recorded in the automatic urinator.

Upon testing the autonomic nerves in seventeen cases of spinal-cord injury and tracing the changes in internal pressure and in capacity of the bladders, it had been found that an application of adrenalin caused no change in either the pressure or the capacity. Atropine made no notable change but methantheline bromide and diphemanil methylsulphate produced a remarkable lowering of internal pressure and increase of vesical capacity, regardless of the level or the completeness of the lesion in the spinal cord. Acetylcholine chloride and vagostigmine caused no change, but pilocarpine had produced characteristic changes, raising the internal pressure and reducing the capacity when the spinal lesion was complete, regardless of the level, and merely raising the internal pressure without causing a change in capacity when the lesion was incomplete. When lumbar anaesthesia is administered, the internal pressure is raised and the capacity is increased in injuries of the upper portion of the cord, regardless of the completeness of the lesion; but when the lesion is lower, such changes appear only when the lesion is incomplete, no change in either the internal pressure or the capacity of the bladder being caused when the lesion is complete. Similar results were obtained following block anaesthesia at the dorsal sacral foramina. Upon general anaesthesia with cyclopropane or thiopental sodium, no change occurred when the lesion was complete, but the internal pressure changed and the capacity increased when it was incomplete.

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From the above results, it may be deduced that the sympathetic nervous system is not involved in the contraction of the bladder, while the parasympathetic system, the vesical parietal plexus, the sacral and the upper centers participate in bladder contraction.

Such findings will give a theoretical basis to the methods of treating and training of paralyzed bladders and the use of automatic urinators. They may be of service in distinguishing complete lesions from spasm and contracture, in treating reflex, hypertonic and atonic bladders, and in preventing backflow into the ureters.

*Experimental Research on the Influence of Immobilization of Limbs in Various Positions on the Excitability of Muscles.* In experiments with rabbits weighing 2.5 kilograms, one of the hind limbs was immobilized in plaster splints. Three positions were used; the other three limbs left free. Immobilization was as follows: Group A: the knee joint was slightly bent and the ankle joint was slightly dorsiflexed. In this position, the gastrocnemius was under medium tension. Group B: the knee joint was extended to the maximum and the ankle joint was put in the extreme dorsiflexed position. Here the gastrocnemius was in extension. Group C: the knee joint was bent to the extreme and the ankle joint was put in plantar flexion. The gastrocnemius was in a relaxed position.

For the purpose of studying the effect of fracture on muscle excitability with the limb immobilized in such positions, DR. M. IWASE[60] had fractured the leg bone transversely on one side at operation and fixed the fragments with a medullary nail. He had then immobilized the limbs in each of the positions described above, and designated them as Groups A′, B′, and C′.

The plaster splints were taken off these rabbits according to a time schedule, and after exposing the gastrocnemius, the stretch reflex was studied by direct traction. The threshold of the action voltage of muscles had been studied as it appeared on direct and indirect stimulation from a discharge tube connected through a high-frequency coil. The wave forms were measured at maximum muscular contraction and during the refractory period of the muscle.

It was found that (1) the stretch reflex is greatly impeded with the lapse of time. In Groups A and B, no case showed tonic reaction after two weeks. In Group C, the reflex is apt to appear transiently in the first week, and generally speaking, the disturbance is less marked. Groups A′ and B′ show results similar to those obtained in Groups A and B, but the inhibiting of the reflex is much greater in the former. (2) The threshold of the minimum action voltage by indirect stimulation is lower in Group A than in the control group within four days after the operation, but rises above the latter after the second week, rising much further in three to four weeks. In Group B, it is lower for the first two weeks and rises in the third or fourth week but never goes much above the control value. In Group C, the threshold value is low, remaining below that of the control throughout. (3) The refractory period after direct stimulation is not changed in Groups A and C and is only slightly prolonged in Group B in the first week, but this refractory period is protracted in all three groups after the second week. The refractory period after indirect stimulation is prolonged in all groups in the first week and the tendency is strengthened with the lapse of time.

In summary, the excitability of the muscle is lowered by immobilization in general. When the limb is fixed in a position causing overextension of the muscle, the drop of the excitability is quite apparent from the early stage, but with the muscle fixed in a relaxed position, the lowering of excitability is less, even showing a temporary rise in the early stage of immobilization.

When the limb is fixed in a position between the two extreme positions, the effect is also intermediate. Fracture has the influence of further reducing the excitability. The elements most affected in the early stage are the receptors and the neuromuscular junctions, the change in the muscles themselves following them.

*Study of the Function of Normal Human Muscles of the Lower Limbs.* The descriptions of the functions of the muscles by various authors are often in disagreement, owing to reliance on morphological inferences. DR. N. TSUYAMA[61] and DR. R. SUZUKI[62] endeavored in their report to analyze the functions of the muscles of the lower limbs of normal persons, employing electromyograms made by needle electrode induction.

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1. The muscles holding the plantar arch. When the plantar arch is pressed flat on weight-bearing, reflex contraction is observed in the flexor hallucis longus, the tibialis posterior, the abductor hallucis, and, to a less extent, by the flexor digitorum and the abductor digiti quinti.

2. Correlation of the muscles taking part in motion of the ankle joint. (a) Plantar and dorsiflexion of the foot: when the foot is dorsiflexed, the tibialis anterior begins to move first, followed by the extensor digitorum longus, and, near the end of the movement, the extensor hallucis longus comes into play. When the foot is plantar flexed, the gastrocnemius first begins to contract, then the peroneus longus and brevis, later the flexor hallucis longus and the flexor digitorum longus and, finally, the tibialis posterior joins the movement. (b) Complex movements at the ankle joint: at the ankle joint pure pronation, supination, abduction, or adduction cannot be made; such movements are always complicated with plantar or dorsal flexion. The authors have plotted the locus described by the tip of the great toe on a glass plate and marked this together with an electromyogram on an oscillograph every time it passed an equidistant point on the locus. Thus, the locus of the great toe was divided into four quadrants, and the scope and conditions of the activity of the different muscles were investigated by the authors.

3. Correlation of muscles in movements of the knee joint. (a) Extension of the knee joint: when the leg is extended from a vertical hanging position, the rectus femoris and the tensor fasciae latae contract from the outset and the vastus medialis and lateralis begin to contract much later. (b) Flexion of the knee joint: the long head of the biceps femoris and the sartorius begin to move first, followed by the semitendinosus and, then, the semimembranosus, the gastrocnemius, the short head of the biceps femoris, and the gracillis join the movement. (c) Rotation of the knee joint: there is a considerable difference between that which has been accepted hitherto and the results obtained by the authors. Those muscles which have been considered to be the internal rotators, namely, the semimembranosus and semitendinosus, the gracillis, and the sartorius, were found to have no part in medial rotation. In medial rotation, the tibial head of the gastrocnemius is found to be active, but the chief factor seems to be the popliteus, which is hard to reach with the needle electrode. In lateral rotation, the biceps femoris, the tensor fasciae latae, and the fibular head of the gastrocnemius probably come into action.

*A Study of the Stabilizing Operations of the Foot.* DR. S. MIYAGI[63], DR. T. YANO[64], and DR. S. TANAKA[65] reported their experience on the Orthopaedic Service of Kurume University with various stabilizing operations on the foot, including Nové-Josserand's method, Lorthioir's method, the talocalcaneal and Chopart's arthrodesis, and the anterior bone-block performed on 107 feet deformed as a result of poliomyelitis, Little's disease, congenital causes, and injuries.

The youngest of the patients at the time of operation was four years of age, and about half of the total number were under fourteen years of age. The majority of the cases were followed roentgenographically for more than six months.

The union between bony surfaces after articular resection began in about three weeks and the union of bony trabeculae began to be observed in three months after the operation. Of these cases, about 43 per cent. showed unfavorable results, such as delay in fusion, non-union, misfit at the ankle joint, osteo-arthritis, and avascular necrosis of the talus. Poor union was common in infants; the other complications were seen in adults.

After operations which decreased the deformity and improved the stability, fifty-seven patients out of sixty-three had improvement in their ability to walk. Most of the patients who had had to use crutches before the operation became capable of unassisted walking. Fatigue from walking was also alleviated in many instances but the complaint of pain was heard more frequently among those who had recovered good walking ability, unfavorable roentgenographic findings not always being related to such findings.

To ascertain how the results of the operation affected the daily lives of the patients, the use of their footwear was first investigated in forty-four cases. Fourteen (32 per cent.) of the patients were inconvenienced in wearing *geta*, or Japanese wooden clogs, this being more frequent in the patients who lacked the ability to flex their first and second toes. Next, as to their sitting postures, nine (24 per cent.) of the thirty-eight patients with successful arthrodesis combined with the posterior bone block were enabled to sit or kneel upright in the manner of the Japanese, their average angle of plantar flexion of the foot being 106 degrees by roentgenograms and 122 degrees on an average by clinical observation. Of the patients subjected to arthrodesis alone, 43.7 per cent. were able to sit upright, but none of the patients who were operated upon according to Lorthioir's method could do it. However, the patients who could not take the formal upright sitting position were enabled to take some freer, if not upright, kneeling position on the floor, and considering the extent of over-all functional improvement, such an inconvenience was amply compensated.

Investigations were also made of the changes in the footprint, the manner of walking, and the length of the stride of the patients who had had operations. The improvement of function in the paralyzed feet following stabilizing operations was strongly influenced by the individual inurement to new conditions, and from this viewpoint, and also from the viewpoint of change of bone and cartilage following the operation, it is desirable that the operation be performed before the tenth year of age is attained, so that the individual adaptation to the use of the improved foot might be more easily effected.

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*An Experimental Study of Tuberculous Foci of Bone and Joints Produced by Inoculation.* Inasmuch as Dr. Y. Shichinoe[66] and his colleagues had used ribs excised in thoracoplasty on tuberculous patients as material for homogenous freeze-dried bone-grafting, they felt obliged to investigate the fate of tubercle bacilli in such bones.

Tubercle bacilli were injected into the knees of five guinea pigs; 0.1 cubic centimeters of the material, composed of the Nakano strain, was used for each injection; the concentration was 1 milligram of bacilli per cubic centimeter. Twelve weeks afterwards, when incidence of tuberculosis had been ascertained, the bones of the infected knee joints were excised, ground, and part of the ground bone was freeze-dried. All of the material was subjected to ultraviolet irradiation for periods of thirty, sixty, or 120 minutes. Aqueous extracts of these bone chips were inoculated in Ogawa's culture media. The results obtained were as follows: in the non-freeze-dried specimens, the counts of viable tubercle bacilli decreased according to the length of irradiation. Even in the specimens irradiated for 120 minutes, there were found some living bacilli. In the freeze-dried preparations, no living bacilli were found.

Most of the guinea pigs inoculated intraperitoneally with the supernatant element of these media showed a positive tuberculin reaction in three weeks and frank swelling of lymph nodes, abscesses, and sinuses in nine weeks. Non-freeze-dried bone extract always gave similar results, regardless of the amount of irradiation they were subjected to. When freeze-dried bone extracts were used, those irradiated over thirty minutes brought about an alleviation of the symptoms, some of the animals inoculated with extracts of specimens irradiated for 120 minutes being free of any pathological change.

The method of freeze-drying practised by the author was to cool the bones suddenly to $-80$ degrees centigrade and then to dry them under a pressure of $10^{-5}$ millimeters. The author concludes that the growth of bacilli in the specimens seems to be strictly inhibited under such conditions.

*Experimental Study of the Influence of Immunization on Tuberculous Foci in Bone Marrow.* Dr. S. Nishi[67], Dr. K. Ebata[68], and Dr. T. Sato[69] reported their investigation of the relation of blood immunization and tuberculous foci in bones.

1. After rabbits were made tubercular by inoculating tubercle bacilli of the human type into the auricular veins, bacillus-destroying antigen was given intravenously at various periods three times every second day; the fall in blood immunization was measured. It was found that the fall was largest in the second and fourth weeks after infection. Pathologically, a large caseous focus was formed in the liver, but no marked change was observed in the bones and the lungs, showing that the foci in the bones and the lungs are probably not influenced by the change in blood immunization.

2. The fall of blood immunization against bacilli invading the blood was also marked in the second and the fourth weeks after infection; frank seemingly allergic change of focus was observed in the liver, but, in the bones, only some disseminated foci appeared to a somewhat notable extent, no progress being seen in the existing foci.

3. When a large quantity of viable bacilli was inoculated between the dorsal muscles and the vertebrae, however, the allergic response in the liver was not greatly increased, the change appearing only very gradually; no change occurred in the bones.

4. When viable bacilli were inoculated directly into the bone marrow, the liver was not at all affected, but the pulmonary foci are severely influenced. Similar results are obtained when bacillary débris is inoculated intramedullarly.

From the above, the authors conclude that with respect to blood immunization, the various organs in the body were not always interrelated. Especially, the foci formed in the bones are not directly influenced by blood immunization, showing special change factors that are independent.

*Experimental Study of the Bacterial Count in Foci of Bone Tuberculosis.* Dr. S. Nishi[70], Dr. T. Hemmi[71], Dr. T. Sato[72], Dr. Y. Sambe[73], Dr. N. Hatta[74], and Dr. T. Masuko[75] reported their investigations in this field. For detecting bacilli in tissues, Ziehl-Neelsen's method, Kuroda's method, and Matsuoka's method were used.

Adult rabbits were inoculated intravenously with 0.1 milligram each of tubercle bacilli of the human strain, and, in approximately two weeks, reactive cell-mass foci were formed in bones. At this time, only a few bacilli were found per focus. In four weeks, typical nodes had been formed and numerous bacilli were found where the foci had become caseous, in most cases causing death of the animals. When the animal survived, the bacilli decreased noticeably, beyond easy detection. This course shows the change in intramedullary immunization in inverse proportion.

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Upon inoculation with a fixed quantity of the bone marrow of the rabbits, each week after infection, inoculated mice showed pathological changes in proportion to the ease in detecting bacilli in bone marrow; but it must be noted that even the bone marrow of rabbits, seemingly completely cured, are virulent enough in the sixth or seventh week after infection to cause formation of tuberculous foci in mice.

*A Study of Bone and Joint Tuberculosis Using $Ca^{45}$.* Dr. S. Maebara[76] and Dr. T. Tanabe[77] injected 0.1 cubic centimeter of saline containing 0.1 milligram of Frankfurt strain of tubercle bacilli into the knee joints of guinea pigs in normal health to cause artificial joint tuberculosis, and the effects of isonicotinic acid hydrazide, para-aminosalicylic acid, streptomycin, x-irradiation, and the same in combination with use of calcium tungstate were followed up utilizing $Ca^{45}$.

The calcium content was found to be lowered somewhat down to the seventh week after the inoculation in the blood, as well as in the bones, not only on the infected side but also on the unaffected side.

When the above medicaments were given, the reduction of calcium content could be kept down to the minimum, the content showing even a slight increase in the cases in which isonicotinic acid hydrazide and para-aminosalicylic acid and streptomycin, or x-irradiation and calcium tungstate were used in combination.

The calcium content in bones in these cases showed a general tendency to increase steadily for fifteen weeks, although some fluctuation was observed within this period.

In the case of simple application of x-irradiation, the calcium content is influenced by the quantity of the irradiation. When the irradiation exceeds 200 r, the calcium content goes on decreasing with time, apparently due to the continuing of the prevalence of injury by x-irradiation. When calcium tungstate is used at the same time, irradiation of 200 r results in a decrease of calcium content beginning only in the fourth week of the treatment.

It is not easy to interpret the mechanism of the action of antibiotics from the mere fact of increased calcium metabolism following the administration of streptomycin, isonicotinic acid hydrazide, and para-aminosalicylic acid. The authors propose the hypothesis that the administration of such antibiotics relieves the organism from the general restraint of the metabolism caused by tubercle bacilli, so that a new status of metabolism takes place.

*Study of the Treatment of Tuberculosis of the Hip Joint.* The effects of the following four methods of treating tuberculosis of the hip joint in the late stages had been observed and were discussed by Dr. T. Ito[78] and Dr. S. Ueki[79].

1. Cleansing of foci: this method was used in twelve cases. Adults have a chance of early bony ankylosis, and cure with mobility was assured in three infants, two of whom have a range of 70 degrees of flexion three years after the operation. This operation is the basis of all methods, and many patients may be cured by this operation alone. This is especially true in infants, in whom mobility may be preserved.

2. Approximation of both ends of the affected joint: when the injury to the floor of the acetabulum is severe and the approximation of both ends of the joint is obstructed, ankylosis of the joint can be expedited by excising the obstructing agent (for example, the remnant of the proximal end of the acetabulum) following cleansing of the focus.

3. Weight-bearing by the affected joint: in two patients in whom extra-acetabular pseudarthrosis had formed in the adducted and flexed position of the thigh, the subtrochanteric osteotomy was done and active walking and weight-bearing were prescribed. Osseous ankylosis was brought about in six months by this procedure.

4. Activation of the bony elements about the focus to unite (by Robertson-Lavalle's method and intra-articular bone transplantation): pieces of bone taken from the greater trochanter were inserted through the joint. The ankylosis was good in those sections in which bones had been transplanted but it was not as good in other parts. This is probably due to insufficient load placed on the latter parts as a result of the transplantation and leads to delayed union.

Accurate fitting of the joint and adequate load expedite bony ankylosis in adults, and especially the placing of sufficient load seems to assure satisfactory results.

It is recommended that bone transplantation be refrained from when cure of the joint may be hoped for with mobility, especially when the patient is an infant.

*Results of Excision of Joint Tuberculosis.* Dr. K. Ohya[80], Dr. F Sawada[81], Dr. N. Ando[82], and Dr. C. Aizawa[83] reported on late results with reference to relapse, weight-bearing capacity, deformity, and mobility after joint excision. The subjects were as follows: fifty-seven patients who had been subjected to excision alone and forty-four patients who had had intra-articular bone transplants in addition to excision (excluding cases in which joint fixation was applied in combination). The time between the operation and the final follow-up varied from three months to five years.

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1. In 98 per cent. of the patients who had undergone joint excision alone and in 98 per cent. of those who had had the combination of joint excision and autogenous bone-grafting, the operated wounds healed primarily, without relapse or sinus formation.

2. In eighty-two patients who had been operated upon more than three months previously and to whom no special treatment was prescribed for re-acquiring mobility, the best results were found in the patients in whom chemotherapy and conservative therapy were used in combination, followed by results in those who had the usual conservative therapy only. The angle of mobility was ascertained to be about one third of the normal range in most cases, but there were a few cases of total loss of mobility.

3. When the patient became able to stand on the affected limb alone for more than five seconds without feeling pain, the weight-bearing capacity of the operated part was regarded as restored. By such a criterion, it was found that the average time necessary to regain capacity to bear weight in the hip joint was 7.1 months, in the knee joint 5.5 months, and in the ankle joint 5.7 months.

4. The shortening of the limb following joint excision was 2 per cent. in patients in whom chemotherapy and conservative therapy were applied in combination; it was 3.4 per cent. to 4.5 per cent. when no such therapy was used. This resultant shortening of limbs is the major disadvantage of arthrectomy.

5. As for malformation, five patients were found who complained of bad limb position, probably caused during fixation after the operation.

*An Experimental Study of Operations upon Tuberculous Joints.* DR. Y. ITAMI [84], DR. Y. IWASE [85], DR. E. SEKINE [86], and DR. H. YAMANAKA [87] discussed the influence of movement following arthrectomy of the joints of guinea pigs artificially infected with tuberculosis, considering both the local and general condition. When may arthrectomy be performed most advantageously under chemotherapy?

Upon examining the fate of the tubercle bacilli in the joint by means of fluorescence microscopy and by culture, it was found that the decrease in bacilli was greatest and most prompt in the streptomycin-treated group, followed next by the group which was treated with streptomycin and joint excision, and was least in the untreated group. In the group of animals treated by arthrectomy alone and allowed freedom of movement, the reaction was 100 per cent. positive during the whole thirty-four weeks of observation. It shows that the stimulation due to arthrectomy and joint movement hinders the natural elimination of tubercle bacilli.

When examined histologically, the untreated group and that in which arthrectomy had been performed and freedom of movement allowed are similar, but when streptomycin is administered, the free-movement group show more proliferation of connective tissue and growth of bone than the group kept at rest, showing that free movement is advantageous rather than otherwise.

Arthrectomy and free movement have a detrimental influence on the local and general condition but the administration of streptomycin is seemingly effective enough to counteract such bad effects.

As to the most advantageous time to operate, the authors found that the longer the previous treatment with streptomycin, the lower the frequency of local and general focal reactions, histopathologically. The frequency of detection of bacilli locally also shows the same trend. The change, however, is not significantly appreciable in one to five weeks, and to prevent rampant disease and growth of bacilli the administration of streptomycin presumably has to be kept up for a considerable period.

*Late Results of Cleansing of Foci in Joint Tuberculosis.* The cleansing of tubercular foci advocated by DR. T. KONDO [88], DR. K. YAMADA [89], DR. Y. KIRITA [90], DR. Y. YOSHIMINE [91], DR. M. OHTANI [92], and DR. H. OHTANI [93], especially in combination with streptomycin therapy, shows a capability of wider application. The authors recently had had opportunity to ascertain the results of the operation in 108 patients of 176 operated upon, one to five years after operation. The results may be divided into four classes: (1) excellent (those who are capable of social activity without requiring further medical treatment), (2) good (those recovered to the degree that little medical care is required), (3) poor (relapse or aggravation), and (4) death. Excellent results were obtained in 54 per cent. and good results in 37 per cent., these two classes alone making up a little more than 90 per cent. of the total.

When classified according to time elapsed since the operation, the group examined at one to two years comprised 15 per cent. excellent and 80 per cent. good results; that at two to three years, 49 per cent. excellent and 19 per cent. good; that at three to four years, 73 per cent. excellent and 4 per cent. good; and the group at four to five years, 91 per cent. excellent and 9 per cent. good. It will be seen that the more time which has elapsed after the operation, the better the results.

The best results occur in the joints of the extremities following operation, excellent results totaling 47 per cent. in cases involving the hip joint, 50 per cent. of cases involving the knee joint, 73 per cent. of cases of the ankle joint, and 61.5 per cent. of cases of the sacro-iliac joint. Tuberculous spondylitis was found to be the hardest to cure, only 31 per cent. of these patients being classified as having excellent results.

Abscesses or sinuses were found in 84 per cent. of the entire series before operation, but at the time of the follow-up study only 9 per cent. had such defects.

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Upon x-ray examination, it was found that 67 per cent. of the cases of spinal caries showed a spinal-fluid block, and only 4 per cent. of joint cases showed bony destruction, residual sequestrum, or relapse, the remaining 5 per cent. showing frank sclerosis of bone. Of these, 39 per cent. had bony ankylosis, and in 1 per cent. the joints are still mobile, without showing sign of relapse.

From the above results, the authors conclude that the cleansing of the focus, together with the use of streptomycin, is a dependable and rational operative method, if practised upon appropriate cases.

*On Conserving Movement Following Operation for Tuberculosis of the Knee Joint.* DR. I. MIKI [94] and others presented their views on the degree of conservation of movement which may be expected depending on the stage to which the disease had progressed at the time of operation. They had based their views on their experience in seventeen patients who were observed from one to four years.

Most of the patients treated were adults suffering from the synovial type with hydrops of the joint, the roentgenograms showing atrophy of bone and narrowing of the joint space.

The progress of the disease was inhibited as much as possible prior to the operation, so that the excision of the focus could be minimal. Partial synovectomy was the operative choice. The present status of the eight cases in which the mobility was successfully conserved shows a maximum range of movement of 90 degrees and a minimum of 10 degrees, ranging from 20 to 30 degrees in most cases. In general, the findings in these cases revealed that the pathological changes were limited to the synovial membrane, almost no change being seen in bone, except for some sporadic localized foci of very small size with a strong tendency to proliferation. The tuberculous process was also inactive in these cases.

The general condition of the seven cases in which mobility had not been successfully conserved showed that the bone foci had already progressed so far that they were clearly demonstrable in roentgenograms; infiltration had occurred into the deeper parts of the joint capsule. Spread of the disease to cartilage, existence of foci with strong exudative changes, and failure to arrest the general progress of the tuberculosis were found in combination with tuberculosis of other joints.

The authors are of the opinion that the cure of tuberculosis of the joint with preservation of physiological mobility has become not exceptional but usual, even in treating adult patients.

*A Study of So-called Cured Tuberculous Spondylitis.* DR. S. NAKAMURA [95], DR. H. SABUROMARU [96], DR. T. TACHIBANA [97], and DR. H. KOIWAI [98] had selected 100 cases of the disease which were treated at the Tamaura National Sanatorium and which showed stability, for the time being at least, clinically and by x-ray examination. In each there was a high probability of non-recurrence as gauged by standards of ordinary daily life. They undertook to investigate the prognosis in this series. There were seventy-one male and twenty-nine female patients, with a total of 104 treated foci among them. Forty-eight of the 100 patients were leading normally healthy lives, fourteen of them with and thirty-four without corsets.

The time of onset of the first attack ranged between five and forty-one years of age, the average being twenty-three years. The period elapsed from the onset to the time of the investigation ranged from three to twenty-two years, the average being seven years and nine months.

The cured cases, examined by x-ray, comprised five types: fifty-two cases had resulted in interbody fusion, twelve in partial fusion, twelve in fibrous ankylosis, twenty-one in bridging, and three in postoperative loss of the intervertebral spacing. Classified by region, all of the cases of cured thoracic caries were in the interbody-fusion group, those of thoracolumbar foci showed bridging as well as interbody fusion; bone bridges prevailed in more than one-third of the lumbar cases, but in lumbosacral cases, bone-bridging was less in evidence.

Upon following up the process of interbody fusion during recovery, the authors find that there are stages of contact, interlocking, dovetailing, and adhesion between the affected bones. The length of time between the first contact and the final fusion is from six months to two years; fourteen months was the average. Such block formation and adhesion constitute signs of effective cure, but since bone-bridging is not reliable as a sign of cure and for judging recovery, reliance must be chiefly on the findings of repair in the foci. Hence, the determination of the completion of cure is difficult, and long-continued observation is necessary. Most cases of the partial-fusion type are similar in this respect to the cases of the bone-bridge type.

The time required from the onset of the disease to reach the state of cure varies in different individuals, but from the data on cures resulting from interbody fusion of two foci in the thoracic region, it was computed to be about three and a half years; patients with multiple-foci took longer. The length of time seems to be unaffected by complications including paralysis, but vertebral fixation rather prolongs the time required for cure. The cures in the cases of complete and partial interbody fusion of lumbar and lumbosacral caries require a longer time than in thoracic cases, averaging five and a half years in general, although individual deviations are to be expected. In cases with bone-bridging in the lumbar and lumbosacral regions, individual deviations are even more pronounced, and the average time required for cure is prolonged to more than six years, some cases with mixed infection having taken more than ten years to arrive at a state of recovery.

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*Tuberculous Spondylitis and Kidney Disease.* Dr. Y. Arihara [99], Dr. A. Hashimoto [100], and Dr. M. Yamada [101] had found ten patients with renal disease among thirty-nine patients with spondylitis. Most of these patients had renal tuberculosis or were suspected of having it. In most of the cases, however, the disease was not so advanced as to cause subjective symptoms.

By position of the bone foci, renal disturbance was most prevalent in patients with caries of the lumbar vertebrae, fifteen of the twenty-six with lumbar involvement having renal disease. Patients with the carious foci in the third and the fourth lumbar vertebrae were most affected.

They had found that the abscesses and sinuses due to caries were in most cases on the side of the affected kidney.

In age, adolescent patients were found to be most liable to complications in the kidney, but the frequency was not related to sex or to the affected side.

The time which had elapsed between the first attack of caries and that of the renal complication ranged from one and a half to over eight years, the average being about three years.

Two patients had renal tuberculosis prior to the incidence of caries.

Of the fifty-two patients in whom surgical operations had been performed for joint tuberculosis, subsequent renal disease developed in four. The other seventeen patients diagnosed as having renal tuberculosis had shown positive reaction in urine tests before surgery, and no marked detrimental effect of the focus-cleansing operation was apparent.

The authors emphasized the necessity of paying attention to the high incidence of renal disease in carious patients, especially, of renal tuberculosis, and recommend making every effort toward early discovery and treatment.

The fact that renal tuberculosis is usually located in the kidney which is on the side of the abscess and sinus formation seems to suggest that, due to some unknown cause, *loci minoris resistantiae* are formed in the affected kidneys.

*Experiences in Cleansing of the Focus in Thoracic and Upper Lumbar Spondylitis.* Dr. S. Kasai [102], Dr. R. Ohashi [103], and Dr. G. Awaya [104] reported a series of ten cases of caries in the thoracic and upper lumbar vertebrae treated by costotransversectomy with cleansing of the focus.

The three patients with abscesses but not much pus showed comparatively good results when treated by expurgation of the foci to the furthest possible extent. When, however, several vertebral-bodies were affected and much pus had accumulated, as in three cases, the sinuses failed to close, even when drainage tubes were inserted after operation, and secondary closure was anticipated. In the two patients in whom abscesses or sinuses formed in the iliac fossa the abscesses were incised and curetted or the fistulae were treated, followed by cleansing of the foci. The results were satisfactory.

In the two patients with long fistulae in the thoracic or lumbar region, of which the walls were densely scarred, the operation had to be extensive, because of the length of the sinuses, and there was much bleeding. The sinuses were first excised; the focus-cleansing followed.

In cleansing foci from the dorsal side in cases of thoracic caries, the area of the exposure is small and there is danger of insufficiently effective cleansing.

*Vertebrotomy in Cases of Vertebral Tuberculosis.* Dr. S. Mizuno [105], Dr. N. Unabara [106], Dr. H. Shimazu [107], Dr. Y. Toyoshima [108], and Dr. H. Arima [109] reported having tried thorough expurgation of foci in vertebral caries; through a paravertebral incision, subperiosteal excision of the transverse process was done, or, in the case of thoracic caries, excision of the ribs down to the heads. The approach to the vertebra was then made between the pedicle and the articulation of the body with the ribs above. In age the patients ranged between seven and fifty-four years. Twenty-three patients were treated by twenty-seven operations. In some of the patients with signs of recovery, roentgenograms showed an interbody fusion of the vertebrae in which there had been tuberculous foci filled with large quantities of pus and granulation tissue; in some, shadows which appeared in roentgenograms and which seemed to be due to sequestra were in truth due to scar tissue.

Upon expurgation of the focus effected in this way, some showed recovery to nearly the normal state through rapid bone formation of the curetted vertebral body and some showed formation of complete interbody fusion.

When a case was complicated by compressive myelitis, the dorsal side was opened as above and then a window was cut into the vertebral canal from the pedicle in order to eliminate the cause of compression. Such lateral vertebrotomy was done on eight patients on eleven occasions. The factors causing the compression were chiefly granulation and pus. In comparison with laminectomy and costotransversectomy, which are usually practised in such cases, this newer method has the advantage of direct and thorough decompression and, consequently, there is a better chance of success.

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*Results of Spondylodesis for Tuberculous Spondylitis.* **Dr. A. Miyazaki**[110] reported that since 1947, eighty-one cases had been operated upon by means of the spondylodesis of Calvé-Otterloo.

Location of the foci: forty-one cases of lumbar caries, twenty-seven thoracic, seven thoracolumbar, one cervical, and the others undefined. Forty-nine patients had been treated for involvement of two vertebral bodies, thirteen for three, seven for four, six for one, and the others for more.

From a study of roentgenograms following operation, it was found that there were two types of cure. One group showed increase in bone formation and the other group had little bone formation but progressive repair of the diseased area. The grafted bones grow very firm in one to two years after the operation, but after the lapse of four years it seems that the transplanted bones are replaced. In fourteen of the eighty-one, foci were formed in other vertebrae after operation.

On investigation of the status of thirty-six of the eighty-one cases, in which more than three years had elapsed after operation, it was found that twenty-five showed good results and the remaining eleven included unimproved cases, relapses, and deaths.

As for the time of surgical operation, it was found that two years and more after first incidence was presumably safe, and good results were obtained. Rest after operation should continue for six to eight months.

Deaths numbered five. This seems to be far lower than the mortality from conservative treatment.

*Study on Spondylosis Deformans Caused by Special Work at the Daiya(stone) Quarry.* **Dr. K. Kamimaki**[111] and **Dr. Y. Takase**[112] noted that the peculiarity in Daiya-seki quarrying consists in the repetition of rather simple but very heavy labor and in the fact that most of the workers work many years. The workers work in a posture of forward flexed spinal columns, heaving and downing pick-axes, the bending and stretching movements of the spinal columns centering on the lumbar segments. Such bending and stretching movements are repeated 20,000 to 28,000 times daily.

Examinations were made of 108 such workers, twenty-two to sixty-seven years of age, who had worked for one to forty-one years, average age being 24.3 years. They had begun work at an average age of 21.7 years; of these, 55 per cent. were teen-agers.

Their roentgenograms showed spondylosis deformans. The disease progressed with age, the early signs appearing at twenty-two years at the earliest. The deformity became more severe with longer service, but the workers who began working between 14.5 and 23.4 years of age had slighter deformities than those who began working at earlier or later ages. This age range coincides with the period between the appearance and the fusion of the epiphyseal plate, and it is of interest that predisposition to external injury in its broader sense, including repeated compression and tension from the standpoint of period of growth is also apparent here.

*On the Nature of Spondylitis Ankylopoietica.* **Dr. H. Fukuda**[113] and **Dr. R. Ono**[114] had studied the disease by clinical observation and through the results of general examinations and histological findings of sacro-iliac joints of ten patients. Their findings suggested that the condition was one of a chronic inflammatory nature which, histologically, suggested collagen disease in an early stage. The evidence in the blood vessel walls seemed to indicate infectious or rheumatoid disease.

*On Clinical Application of Parotin in Orthopaedics.* **Dr. K. Nozaki**[115] and **Dr. H. Motokawa**[116], had studied the pharmacology of parotin (salivary-gland hormone) in orthopaedic diseases. Doses of ten milligrams twice a week were given for two months in succession per patient. Of the six cases of spondylosis deformans, one showed a good effect and five were negative. Of the five cases of osteo-arthritis of the knee joint, two showed improvement and in three there was no apparent effect. The cases in which there was improvement showed the result in four to six weeks. One case each of osteo-arthritis of the hip joint, Heberden's nodes, and "frozen shoulder" showed no improvement in pain or mobility. Two cases of achondroplasia and one case of osteogenesis imperfecta showed no betterment. Of the two cases of dystrophia musculorum progressiva, one showed improvement in walking ability subjectively as well as objectively, improvement in muscle atrophy of the thigh, and decrease of creatine in the urine.

As to side-effects, intramuscular injection of parotin sometimes caused local reddening, pain, and the general reaction of lowered appetite, lassitude, and feeling of cardiac oppression, and sometimes general urticaria and local erythema that might be called toxic exudative erythema. These side-effects, however, subside with the repetition of injection and in no case did the authors have to stop the administration of parotin.

*Criteria of Effectiveness and End-Results of Treatment for Chronic Rheumatoid Polyarthritis.* **Dr. G. Shimizu**[117], **Dr. T. Sageshima**[118], **Dr. S. Sumiyoshi**[119], **Dr. M. Nakada**[120], and **Dr. S. Tanabe**[121] reported an end-result study of 113 cases in a series of 240 cases of rheumatoid arthritis treated from 1947 to 1955. Treatment consisted in excision of "pressure-control" nerves, drug therapy, and orthopaedic measures. In the classification and the estimation of results, the standards proposed by the American Rheumatism Association at the International General Meeting on Rheumatism were followed.

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Treatment with drugs proved ineffective against relapse, but the therapy adopted by the authors resulted in effective cure in 55 per cent. of the cases in two to seven years following treatment. The control cases not subjected to the therapy showed results of improved joint function in 18.5 per cent. of the cases, and in thirty-seven per cent. the infirmity was aggravated. The hospitalized and treated patients showed improved function in 51.3 per cent. and deterioration in 8.8 per cent. of the total, showing that the treatment had been effective in improving the joint function.

The authors have found that the cases with lighter arthritic change attained better curative effects and functional improvement than the severer cases.

The results proved the more favorable, the longer the time from incidence to operation. No definite relation was found between the site of the disease and the results.

*Study of the Results of Osteotomy for Bony Ankylosis of the Hip Joint with Malposition.* There are many cases of malposition of extremities among patients with ankylosed hip joints, who cannot be subjected to arthroplasty under such conditions. DR. K. SHIMA [122], DR. Y. MIKUNI [123], and DR. S. MATSUI [124] presented the results of their attempts to improve the function of the lower limbs of twenty-seven such patients by performing osteotomy on twenty-eight of the affected femora. In age, the patients, sixteen men and eleven women, were from seven to fifty-nine. In seventeen cases or 63 per cent. of the total, ankylosis developed as a result of hip-joint tuberculosis. The next group consisting of only four had suffered from pyogenic osteomyelitis. With respect to the positions of the limbs, ten were in the abducted and flexed position, nine were adducted and flexed, five were overextended, and four were in excessively flexed positions. Shortening of the afflicted limb amounted to three to six centimeters in six cases, to six to nine centimeters in five, and above nine centimeters in five cases. The operative methods applied were the subtrochanteric osteotomy in thirteen cases, and the femoral-neck osteotomy and the intertrochanteric osteotomy in six cases each. The degree of correction required to regain a position of convenience was determined in each case prior to the operation, the estimated compensatory function of the sacro-iliac joint and the lower lumbar vertebrae being taken into account. The results of the operation were determined in twenty-three cases. The time required to recover walking ability after the operation ranged from four to twelve weeks, with an average of six and one-half weeks. Walking ability was markedly improved in all cases, but in some the gait was not improved as much as had been expected. In general, the patients with marked abduction were much improved by the operation, but adduction ankylosis had not been especially improved. Patients with excessive shortening of limbs should first be treated for this defect, or there will not be much improvement in gait. The most distressing inconvenience in the daily life of such patients with ankylosed hip joints was found to be their inability to assume sitting positions, but of the eight patients who could not sit before the operation, one acquired the ability to sit in a chair, two the ability to sit upright in the Japanese manner and one to sit, although with difficulty. For sitting, it was found that not only the proper position of the hip joint was necessary but also the proper mobility of the knee joints. By osteotomy, some patients with hip-joint ankylosis with malposition of the limbs and with limb function reduced to less than 60 per cent. improved to a level of about 90 per cent. of the limb function of normal persons.

*Determination of the Applicability of Arthroplasty by Testing Muscle Function. After-Treatment.* There are many methods for testing muscle function, but among them the method of testing the hardness of muscles has the merit of being the simplest and being available for any individual muscle. Generally speaking, in the case of ankylosed joints, it is a common peculiarity that the muscular hardness is rather high in the relaxed state and does not rise much during the state of contraction. DR. S. KONO [125], DR. T. TAKIMA [126], and DR. H. HASHIMOTO [127] took as a standard in estimating the muscle power the ratio of the difference of hardness during relaxation and during contraction of the affected muscles as compared to that of the muscles on the uninvolved side. Upon determining the ratio of the difference of the hardness of the extensor muscles of the affected side where there is ankylosis, from that of uninvolved side, the ratio was found to be high in the cases empirically known to be amenable to arthroplasty, such as ankylosis due to injury and to local inflammation, but low in the cases deemed not fit for arthroplasty, such as ankylosis due to tuberculosis and rheumatism. The reduction in muscular power in the course of the ankylosing process does not appear to an equal extent in all muscle groups and was especially marked in the knee extensors and in the abductor-extensor groups of the hip joint. The position of joint ankylosis also affects the degree of reduction of muscle power. In general, the reduction is greater in ankylosis in a poor position than in better positions. The authors deem arthro-

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[127] Niigata, Japan.

plasty applicable when the difference in hardness of the main muscles of the affected side in the relaxed and contracted states compared with that on the healthy side is less than 30 per cent.

The authors presented a series of thirty-two cases of hip arthroplasty, but the results proved much less satisfactory than in cases of elbow or knee-joint ankylosis. From the viewpoint of muscle power, it must be noted that the power of the abductor and extensor muscles in the hip joint, which are of importance in sustaining a load in walking, is found notably reduced, the average muscular power being reduced to less than 50 per cent., except in cases of ankylosis due to injury and osteo-arthritis. Arthroplasty performed without regard to reduced muscle power is prone to result in grave functional deficiency.

Muscle power is markedly lowered in the third and fourth months after arthroplasty, especially in the extensors of the elbow and the knee joints and the abductor extensors of the hip joint. This reduction is not due to a change in the muscles themselves, but seems due to an anomaly in the excitability of the cells of the anterior horns of the spinal cord, leading to obstruction of the transmission of stimuli for muscle contraction from the brain, and caused by tissue damage, shock, and incomplete reparation following the operation. To expedite recovery of the muscle power, forceful after-treatment which might cause pain should be avoided; the restoration of motion in the joints operated upon should be expedited by prescribing mild active and passive movement, while the tissues are protected by traction.

*Roentgenological Study of the Vertebral Bodies of Infants and Children.* DR. K. ITO [128] had made frontal and lateral roentgenograms of 260 normal infants and children under six years of age and measured the vertical and the anteroposterior diameters of the vertebral bodies and the vertical thicknesses of their intervertebral discs, and also followed up the changes in the stages of development of the shape of the vertebrae, of the vertebral epiphyseal nuclei, the Hahn's grooves, and the Schmorl's step-like defect figures.

The third cervical vertebra is the smallest and the third lumbar the highest, generally speaking, but in girls, the fourth lumbar is the highest up to the second year of age. The rate of growth is greater in girls between three and four years of age and in boys between four and five years of age. In the fifth and sixth years, the thoracic vertebrae from the second through the eleventh are larger in girls than in boys. The smallest and largest ventrodorsal diameters are found in the third cervical and the third lumbar respectively.

The thinnest intervertebral disc is beneath the third cervical vertebra and the thickest one is beneath the third lumbar vertebra. In the fifth and sixth years, the thickest discs are found between the transitional vertebrae from the thoracic to the lumbar regions. In boys, the rate of growth is least in the fifth thoracic vertebra and greatest in the third lumbar vertebra, while in girls, the smallest was found to be the third thoracic and the largest the third lumbar vertebra.

The outline of the so-called Schmorl's step-like defect was observed in all segments between the eighth thoracic and the fifth lumbar vertebrae in varying frequency, but was most common in the first lumbar vertebra, being somewhat more frequent in the upper than in the lower surface. By age, it appeared most frequently in the fifth and sixth years in boys and about a year earlier in girls.

The vertebral epiphyseal nucleus appeared in the lateral roentgenograms in the vertebrae between the second thoracic and the first lumbar at the age of two and one-half years to five and one-half years and in the frontal roentgenograms in the segments between the second and eleventh thoracic.

The Hahn's groove was observed from the first thoracic to the fifth lumbar vertebra, both in boys and girls. It appears most frequently in the new-born, with the sixth, seventh, and eighth thoracic vertebral bodies as the center, diminishing above and below them gradually with increase in age.

*A Study of the Architectural Structure of the Trabeculae of the Human Bone.* DR. I. TOCHINAI [129], DR. K. KOIZUMI [130], DR. T. YAMAZAKI [131], DR. M. ISHII [132], DR. K. ICHINOHE [133], DR. Y. SATO [134], DR. M. NOHARA [135], and DR. S. TOJIMA [136] had cut human bones in three planes and had made stereoscopic views of the trabeculae by photographs and roentgenograms of these sections.

They had found the main trabeculae of the vertebrae were grouped in three systems, vertical, horizontal, and diagonal. The vertical trabeculae are most common in the sagittal plane, next in the frontal plane, and least common in the diagonal plane. The horizontal trabeculae cross the vertical and are most clearly observable in the periphery. The diagonal trabeculae emerge from the upper and lower parts of the laminal roots and the right and the left ones decussate mutually.

They had the calcaneus divided into five systems of main trabeculae and two systems of auxiliary trabeculae.

They pointed out that the long bone is a cylinder in which trabeculae emerge from both sides or from the front and from the back, cross each other and pass over into the cortical zone. The trabeculae are best developed in the extension of the cortical line.

*An Anatomical Study of the Soft Parts in the Lumbar Region with Reference to Low-Back Pain.* DR. E. SHIOKAWA [137] had made macroscopic and microscopic observations on the soft parts of the lumbar region, especially of the superficial layer of the dorsolumbar fascia of fourteen adults and thirty foetal cadavera in connection with low-back pain.

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[128] Tokyo, Japan.
[129] Morioka, Japan.
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[134] Morioka, Japan.
[135] Morioka, Japan.
[136] Morioka, Japan.
[137] Hirosaki, Japan.

The number of times the terminal branches of the spinal nerves had emerged from the sacrospinal muscles and the number of times these nerves had entered through the lumbodorsal fascia was larger on the right side than on the left in the adult, but in the foetus the difference was not notable. In the lumbar region, the lateral branches were best developed. This was most readily observed in the foetus. None of them were traced into the opposite side.

Of the types of penetration of the posterior rami through the lumbodorsal fascia, the complex type was most common in the third lumbar segment, in both the adult and the foetus, the distribution of nerves being dense at this level. The form met most frequently was spindle-shaped, which was covered only by connective and adipose tissues, and may be described as structurally fragile.

In silver-impregnated sections, medium-sized medullated nerve fibers were seen following winding courses, in bundles of three to seven strands along with capillaries, through the dense connective tissue of the lumbodorsal fascia. Sometimes the sensory fibers were seen to run to the dorsal side of the fascia and to terminate there. On the dorsal side of the fascia, about twenty bundles of nerve fibers were seen running through the connective tissue composed of sensory non-medullated fibers ending in rather thick terminations in the adipose tissue, and a comparatively large number of non-medullated sensory terminal fibers running in gentle curves immediately dorsal to the fascia and ending in simple ramification or in nodules.

Thus, we may presume that the lumbodorsal fasciae are rich in elements, structurally fragile, and are exposed to mechanical stresses.

*Supplementary Observations in Histological Studies of Nerve Distribution at the Thoracolumbar Area.* DR. T. IGARI [138] reported that he had found the Hirsch type of end organ, encapsulated glomerular corpuscles of sensory nerves, at the ramifications of capillaries from the smallest arteries. These were located in the loose tissue at the transitional zone between the contractile elements of the longissimus dorsi in the deeper layers and the tendons. With respect to the complexity of the glomerulae, these were simpler than those in the skin and simpler than those described in the original report by Hirsch. But the number of special cell nuclei originating as Schwann's nuclei was comparatively large, and they were generally aligned in the course of the sensory fibers. The vegetative nerves, of preterminal reticular nature, which accompany the sensory fibers, do not enter the glomerulae, but run about the corpuscles toward other small arteries. This shows that these bodies, which are assumed to be concerned with blood pressure and flow, are in close connection with autonomic nerves. The absence of sensory nerve elements innervating the blood capillaries distributed to the muscle fibers of lower order also reveals their significance as the final regulative apparatus concerned with blood flow and blood pressure in the muscle fibers.

Krause-type encapsulated glomerular corpuscles were found in the transitional zones between contractile fibers and the tendons, but they were not related to vegetative nerves.

Concerning muscular sensation, little has been reported in Japan on free, simple sensory-nerve terminations. The author reported having found a small number of medullated sensory fibers, which, after losing their myelin sheaths, ended freely and branched among the muscle fibers.

Vegetative terminal reticula were found in neuromuscular spindles situated in the periphery, and not entering the central part of aggregated nuclei, but the distribution was found to be generally poor and the relation to the blood vessels in the spindles not necessarily close.

The author had examined the motor-nerve terminations of the thoracolumbar muscles of young subjects and found that the terminations form fibrillary reticula, one or two sole-plate nuclei being found surrounding them in kidney or horseshoe form, and not definitely oriented. These end organs crossed the longer axes of muscle fibers and had light granular nuclei.

*A Clinical Study of Osteoplastic Hemilaminectomy in Lumbago-Sciatica.* DR. M. MORI [139], DR. M. HAYASHI [140], and DR. Y. TOKUDA [141] reported having operated upon sixty-eight patients with disc herniation, of whom the majority were treated by osteoplastic hemilaminectomy.

In determining the indications for operation, signs and symptoms as well as the myelograms had been considered. The dependability of such myelograms ranged between 90 and 100 per cent.

Postoperative progress had been divided into three stages: the period of alleviation of radicular symptoms which lasted for about two months following the operation, the period of recovering walking capacity which continued to the fourth month, and the period of recovery of function of the lumbar spine which extended from the fifth month on.

The results following the operation proved excellent, that is, limping disappeared and the ability to walk became normal in most cases. Moreover it was found that functional recovery occurred in the lumbar spine and lower limbs.

Roentgenographically, the majority of the laminae fused in three to four months.

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[138] Sendai, Japan. [139] Takada, Japan. [140] Takada, Japan. [141] Takada, Japan.

Complete cure was obtained in 73 per cent., marked alleviation in 9 per cent., slight improvement in 13.5 per cent., and no improvement in 4.5 per cent. of the cases. Of the thirty-five patients undergoing the operation more than six months previously, 88.5 per cent. returned to the same occupations as before and the remaining 11.5 per cent. had changed their occupation, but none of them were unemployed.

*Improvement in Osteoplastic Hemilaminectomy in Cases of Hernia of Lumbar Intervertebral Discs.* Dr. E. Kondo [142] and Dr. Y. Kirita [143] expressed the view that the essence of good operative treatment for the relief of herniations of lumbar intervertebral discs consists in limiting the operative area to the minimum, consistent with assurance of complete excision of protruded disc tissue and facility in observing the nerve root. The operation should minimize unphysiological or weakening structural change of the vertebrae involved.

(1) When the muscles are detached from the spinous processes, the muscles on the opposite side are not reflected at all or only to the minimum extent required for admitting a retractor. (2) Excision of the flaval ligaments is performed only between the lamina to be excised and the one below it. (3) Only one-half to two-thirds of the interarticular portion of the lamina is excised and through the defect thus created a chisel is inserted into the side of the spinous process parallel to and three millimeters from the surface of the process. (4) When the spinous process has thus been cut vertically along the median line, the portion of the vertebral arch to be removed is excised. (5) After excising this portion of the arch on one side, the medial border of the inferior articular process is cut away together with the attachment of the flaval ligament. (6) After excision of the herniated disc, the excised portion of the arch is returned to the original site. Through these modifications, a field of operation wide enough for extirpation of herniated intervertebral discs and for exposure of lumbar nerve roots is assured, the anatomical and physiological structure is retained, and time and labor in operation are saved. The cut line of the returned arch becomes invisible in about two months and in three months at the latest bony union is complete.

Patients subjected to this improved method number only forty-three to date and the time elapsed after operation is only ten months even in the oldest case, but it may be pointed out that seventeen of them have been completely cured, six recovered moderately, and there is no case of aggravation.

*Extradural Myelography of Lumbosacral Vertebrae by Means of Water-Soluble Contrast Media in Various Positions.* Dr. F. Nakamoto [144], Dr. M. Unemoto [145], Dr. S. Yutaka [146], Dr. S. Wakita [147], and Dr. H. Katayama [148] had injected, as contrast media, fifteen cubic centimeters each of novocain and gelatin-added iodopyraceton or iodopyraceton C through the sacral hiatus using Cathélin's method. Immediately thereafter anteroposterior, lateral, and oblique roentgenograms were made. Extradural myelograms were made by this technique of forty patients with the following findings. (1) It was found that it was possible to examine the dura mater and the nerve roots in detail over a considerable extent, especially with respect to displacement, bending, change in size of nerve roots, and the course of the nerves through the intervertebral foramina. (2) The necessary technique had proved simple and safe, since the contrast media do not come in direct contact with the cauda equina and are rapidly absorbed and excreted. Little side effect had been occasioned.

By this method, the changes in the lumbosacral region occasioned by varying the position of the subject can be readily observed dynamically. Changes unobservable in the usual intradural myelograms can be demonstrated in extradural myelograms made in various positions. For example, an upward shift of the contrasts media at the time of forward bending indicates protrusion of the intervertebral disc, and that on backward bending indicates hypertrophy of the ligamentum flavum.

The authors had compared the roentgenograms made in various positions and measured the height of the intervertebral discs, the size of the intervertebral foramina, and the distance between the spinous processes, as aids to diagnosis. In most cases where unchanged spacing between spinous processes had been found, pathological changes were present in the corresponding intervertebral disc.

*Changes Appearing in the Bones and Joints of the Upper Extremities of Miners Using Portable Rock-Drills.* Dr. M. Ando [149] presented the results of his experiment performed during the operation of a rock-drill. Carbo-microphones had been placed on the wrist, the elbow, and the shoulder of the operator. The average frequency of the strokes of a rock-drill is about thirty per second and the reaction to its vibrations is most shocking. He had observed that the intensity and the irregularity of the vibrations are most telling on the back of the hand, the olecranon, the ulnar styloid process, the radial condyle, and the posterior surface of the acromion, in the order named.

The author had made roentgenograms of 157 cases selected from miners who complained of their upper limbs and who had been using hand rock-drills for more than one year. He found changes in 223 joints of eighty-six cases (54.8 per cent. of the total number of cases examined). The changes were most prevalent and most marked in the elbow joints, next in the wrist joints, and next in the shoulder joints. The chief changes in the elbow joints comprised compression, papillary deformation of the radial head, sharpening, elongation, and hypertrophy of the coronoid process, sharpening and hypertrophy of the tip of the olecranon, spur formation at the attachment of the tendon of the triceps muscle, deformation, spur formation, calcification, and ossification of the cartilage on the volar side of the distal end of humerus, deformation of the trochlea and capitellum humeri, irregularity of their articular surfaces, and hypertrophy of the bones in the olecranon fossa and coronoid fossa. In the wrist joints, deformation and radiolucent areas in the distal end of the ulna and the radius and of the carpal bones had been observed, while in the shoulder joints, deformation of the lower border of the glenoid and of the humeral head, calcification at the attachments of the capsule to the humerus, and irregularities in the joint surfaces of the acromioclavicular joint had appeared.

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[142] Kyoto, Japan.
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[144] Hiroshima, Japan.
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[147] Hiroshima, Japan.
[148] Hiroshima, Japan.
[149] Kyushu, Japan.

With respect to age, the changes became prevalent in subjects over fifty years, being more frequent and severe as the period of time of using the rock-drill increased and as the age when the miner began using the drill was found to be lower.

The subjective complaints did not necessarily correspond to the magnitude of the changes shown in the roentgenograms.

*A Criticism of Methods of Rehabilitation.* Dr. H. Tamura[150], Dr. A. Kajiwara[151], and Dr. T. Fujishita[152] pointed out that rehabilitation of the disabled, both physical and occupational, should be practised, and that the chief emphasis should be placed on exercise, especially resistive exercises, as a means of strengthening muscle power. They felt that there was an urgent need to educate physical therapists and trainers.

*A New Type of Basogram with Emphasis on the Determination of the Rate of Progress of Various Points on the Extremity and the Time of Contact of the Foot with the Floor.* Dr. R. Oda[153] and Dr. K. Nakagawa[154] emphasized that basograms hitherto in use had the disadvantage of producing overlapping recording of a point on the foot, with the result that adequate analyses of the time relations of phases of transposition of each point are impossible. The author presented a basogram which Prof. Iino had devised. He felt the device was an improvement in that it lessened such defects. In this method, the displacement of the object is not projected directly on the basogram, but is recorded by the transposition of a point of light, reflected from a glass rod fixed at a constant distance from the lens. In this way the movements of points in the horizontal and vertical directions are separated. The apparatus is provided with four lenses, which are opened and closed periodically by levers. The first lens records a continuous locus of the movement of the point to be observed on a fixed film, and the time relations of contact with and separation from the floor are clearly recorded by a minute break in the locus. The next lens records, on a film running at uniform speed, only the horizontal phase; the third the vertical phase; and the fourth the times of contact with and separation from the floor together with a series of time marks. The internal structure of the apparatus is so devised that the reels on the right and the left sides make the films run vertically while the film runs on a central reel horizontally. These three films always move with precise isochronism and uniform speed. The four films made with this apparatus are pasted on a single plate of glass, and enable one to make all analyses and determinations of the phases of walking through a synchronized picture record. Thus, the vertical and the horizontal relative positions and the rate of progress in every phase of displacement of the anterior superior iliac spine, the lateral mid-point of the knee, and the fibular malleolus are clearly shown on the films. A vertical line means that the point is stationary and an oblique line indicates the rate of progress. Thus, the relative vertical and the horizontal positions and the rate of progress of any given point in every phase of movement are clearly and analytically indicated together with all the time relations. The recordings provide an indispensable basis for analyses of gait.

*Basogram of a Patient with Ankylosis of the Hip Joint.* Dr. T. Kitagawa[155] and Dr. H. Kasai[156] presented the results of their studies of basograms in hip-joint ankylosis due to tuberculosis, made by either of the two following methods: (1) Three torchlight bulbs each were attached in vertical rows on the shoulder joint, the iliac crest, the greater trochanter, and the lateral side of the knee of a patient. The uppermost bulb of each row was lighted at the moment the heel touched the floor; the central one was lighted continually and the lowermost one was lighted when the fifth metatarsal head touched the floor. In addition, a single bulb was attached to the fibular malleolus and one to the fifth metatarsal head and these were lighted throughout the test. The patient had been made to walk in a dark room and photographs had been taken from the lateral side from a distance of four meters with a camera before which a disc, cut in half, had been rotated to serve as a shutter. (2) In the second method, so-called intermittent photography had been employed, the temporal progress in the walking movement having been made on one film. Black marks were placed on the subject at the same points as those selected for the attachment of the torchlight bulbs in the first method;

[150] Osaka, Japan.
[151] Osaka, Japan.
[152] Osaka, Japan.
[153] Sendai, Japan.
[154] Sendai, Japan.
[155] Niigata, Japan.
[156] Niigata, Japan.

strong light had been applied from before and from behind; and photographs had been taken in a dark room.

Basograms had been made of patients with ankylosis which had occurred in convenient and in inconvenient positions, with and without shortening of lower extremities, and with incomplete ankylosis. Basograms of patients on whom athroplasty had been performed had been studied in comparison.

In general, the basograms of patients with ankylosis of the hip joint in convenient position are similar to those of normal subjects, as far as the horizontal and the vertical movements of spots are concerned.

*Angle and Distance between Steps.* For taking footprints, DR. T. FUKUSHIMA [157] reported the use of a flat course with a goal line. Ten meters beyond the starting point, powdered plaster-of-Paris was strewn in a thin layer and beyond that a sheet of black paper forty-five centimeters in width and 180 centimeters in length was placed on the floor. The subject was made to walk twenty meters in a straight line toward the goal line with that gait which was normal to him, so that two or three footprints were left on the black paper. The footprints during a short run were also recorded in the same manner.

Forty male and ninety female youths took the test.

The subjects, including female subjects, with large laterorotary angles of the limbs showed angles between steps which exceeded the average. The female subjects complaining of Takagi's "latero-torsio cruris" showed a lateral torsion of over 20 degrees. Their step angles were of course larger than the average value, but changes in the angle of lateral torsion and between the steps showed no parallelism. The distances between the footprints of the right and left feet, upon several tests per subject, were not different, the maximum being 11.4 centimeters, the minimum minus 2.3 centimeters, and the average five centimeters in male subjects. In female subjects 12.5 centimeters was maximum, minus 1.9 centimeters was minimum, and three centimeters was the average. In the subjects with genu varum or genu valgum of more than three centimeters, the average between footprints was larger by 3.5 centimeters and four centimeters in male and female subjects respectively.

The angle of footprints in running was 21.5 degrees for the maximum, minus 3.5 degrees for the minimum, and 19 degrees as an average for the right foot; and maximum 20 degrees, minimum minus 10 degrees, and average 13 degrees with the left foot of male subjects; while with female subjects, the maximum was 18 degrees and 15.5 degrees, the minimum minus 7 degrees and minus 9 degrees, and the average 14 degrees and 7 degrees with the right and the left foot respectively. All these values were larger than those during normal walking. But the distance between the steps showed decrease in running, becoming 14.5 centimeters at the maximum, minus 4.3 centimeters at the minimum, and one centimeter on the average, in male subjects, and in females 13.6 centimeters at the maximum, minus 5.5 centimeters at the minimum, and one centimeter on the average.

*Study of the Dynamics of the Lower Extremity. An Analysis of Gait by Means of the Strain-Gauge.* DR. H. MASABAYASHI [158], using a strain-gauge, had recorded and studied the phases of changing loads in vertical, anteroposterior, and lateral directions in normal and pathological gaits. He reported as follows:

In normal subjects the vertical load is greatest when the body weight is shifted on the tuberosity of the calcaneus and least a moment before that tuberosity is lifted from the floor and the fore part of the sole receives the load. The forward load is the greatest when the heel touches the floor. The load during the shift to the right side is felt from the time when the right heel touches the floor to a moment before the tips of the right toes are lifted off the floor, the maximum being recorded when the fore part of the right sole touches the floor.

In patients with Little's disease, cured of spastic talipes equinus but still showing medial rotation of the weight-bearing limb in walking, the variation of lateral loads was marked at the time when the heels touch the floor, but the amplitude of change was small, showing a weakness in the latter half of the phase of standing on the limb and a diminution of the force of progression.

The slight variation of the load in the vertical direction on the affected side in paralytic drop-foot and in patients with a flexion contracture of the knee seems to indicate that, as a result of the supporting of the knee by the hand and as a result also of the spring-like action of the calf muscles in the equinus position, the load borne by the entire affected limb is buffered.

In cases with a shortened lower limb, the time necessary for the toes to touch the floor is prolonged.

The small variation of load in the vertical direction at the time of standing on the affected limb in cases with congenital dislocation of the hip joint is probably due to the so-called "glissement", and the appropriate uniformity of the load on the affected side throughout the time the dislocated limb is in contact with the floor agrees well with the name of "elastic limping".

Comparing limbs with ankylosed hip and knee joints with normal limbs, we find that the time lag between contact with the floor by the heel and contact by the sole becomes shorter as the extremity takes on more of the character seen in club-foot, and the time of maximum forward shifting of the load appears a little later than the time of contact of the heel with the floor.

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[157] Maebashi, Japan.

[158] Tokyo, Japan.

*Studies of the Trendelenburg Sign.* Dr. H. Kobayashi [159] reported his experience in this field of investigation. For the purpose of following the movement of the pelvis during the Trendelenburg phenomenon, he had observed eighteen hip joints by means of ordinary photographs, motion pictures, and roentgenograms made in the standing posture and by x-ray kymograms. He had studied the actions of the muscles controlling these joints through electromyograms, in order to examine their mutual relationships.

For the sake of convenience, the movement of the pelvis accompanying Trendelenburg's phenomenon was divided into four stages, determined by x-ray and x-ray kymogram, as follows: (1) The first of these four is the stage where the subject stands on both legs. The pelvis is maintained in a horizontal position. (2) In the next stage the heel of the affected side contacts the floor. When the affected limb is much shortened, the pelvis is raised on the normal side and moves horizontally slightly to the affected side, causing a scoliosis with the convexity on the normal side. (3) The third stage occurs next in which the body weight is almost entirely shifted to the affected side. When the knee joint of the normal side is slightly bent or the foot of the normal side is lifted off the floor, the pelvis is still above the level of the normal side but begins to sink, and it begins to incline forward and to rotate backward slightly on the normal side. (4) In the next stage the cycle is completed, the foot of the normal side being lifted entirely off the floor. The pelvis is displaced maximally to the affected side, inclines forward, sinks as well as rotates backward on the normal side, and the scoliosis becomes marked. When no limb shortening is present, the second stage does not develop. When there is frank osseous support in the acetabulum or in any other portion and there is no Dupuytren's phenomenon, the third stage is the last. In the case of congenital dislocation of the hip in which an osteotomy has been performed, only the first two stages are noted.

Upon electromyographic observation, the discharge from the glutaeus medius is stronger on the affected side, while in normal cases in the standing posture there is almost no discharge recorded. When the Trendelenburg phenomenon is present to a marked degree the relatively strong discharge from the sacrospinalis appears in contrast to the normal, the discharge from the side of the supporting limb being stronger than that from the free limb.

From the above it is concluded that the presence of "glissement" is an important factor in the gait in the presence of the Trendelenburg phenomenon.

*A Method of Making Roentgenograms of the Hip Joints of Infants and Children and Its Clinical Application.* Dr. T. Morotomi [160], Dr. T. Saito [161], and Dr. T. Nakamura [162] presented their method of obtaining the proper exposure for roentgenography so as to portray the relative positions of the femoral head and the acetabulum, the shape and angle of the acetabulum and of the sliding groove, and of the new acetabular fossae. Superimposed shadows are avoided such as those of the ischial tuberosity and of other structures which may cause difficulty in reading the roentgenograms of the hip joint. This had been done by means of rotating exposures. The first exposure is made with the patient in the supine position, with the x-ray tube inclined 30 degrees caudalward and 15 degrees medialward and the axis of the rays directed through the femoral head. The second exposure is made with the patient in the prone position, with the tube inclined 45 degrees caudalward and 15 degrees laterally. In the first exposure, the upper half, and in the second exposure, the lower half and border of the acetabulum are clearly recorded. The authors had also developed the formulae for deducing the angle and the actual distance in space of a point on the roentgenograms made by this method.

Concerning the clinical application of the method to cases of congenital dislocation of the hip, traction can be directed to coincide with the direction and formation of the sliding groove ascertained by this method. When plaster-of-Paris bandages are being applied, knowledge of this direction assures minimum trouble from the bandages and the estimation of the effect of the reduction is made easy. During treatment, new-bone formation on the edges of the sliding groove may be accurately observed. When the shelf operation is to be undertaken, the appropriate position and the size of the acetabular roof can be measured and the proper procedure can be determined to meet the needs of the case.

*Publicizing Treatment of Congenital Dislocation of the Hip Joint.* Dr. K. Nozaki [163], Dr. T. Nagai [164], Dr. H. Ogaki [165], and Dr. K. Noguchi [166] reported their experience in endeavoring to effect a wider diffusion of knowledge of the treatment of congenital dislocation of the hip joint. They had made (1) early examinations of nursing infants to detect dislocation and (2) they had instituted early treatment by using diaper holders. As an aid to early detection, the authors had devised an apparatus for making six-by-six-centimeter roentgenograms of suspected hips.

Of 2,809 babies examined at a certain health center in Tokyo, 374 suffered from limitation of hip abduction of whom 177 were examined by x-ray and thirty-five were, as a result, diagnosed as having congenital dislocation. If all of the 374 afflicted babies could be thus examined by x-ray, presumably seventy-one cases of congenital dislocation would have been detected. Add to this number of cases the number of cases of congenital dislocation detected by clinical examination only and one arrives at the total of sixty-one or 2.2 per cent. of the total 2,809. The thirty-five identified cases were immediately given treatment with diaper holders made of two x-ray films and provided with suspenders, which are so arranged as to assure frog-leg position of the extremities. Of the thirty-five cases, twenty-five finished the treatment by the use of diaper holders alone, twenty-one cases successfully, and four cases unsuccessfully. The age of the successfully treated patients averaged 4.3 months, while the uncured patients were all above six months. This fact also bespeaks the necessity of early detection and treatment.

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[159] Yugawara, Japan.
[160] Hirosaki, Japan.
[161] Hirosaki, Japan.
[162] Hirosaki, Japan.
[163] Tokyo, Japan.
[164] Tokyo, Japan.
[165] Tokyo, Japan.
[166] Tokyo, Japan.

For patients who had difficulty in coming daily to the hospital, the authors had applied an apparatus which is called the moveable hip-joint-bridging plaster. With it they had effected reduction in the frequency of required hospital attendance. Twenty-three patients had their treatment completed under this method, of whom 65 per cent. showed excellent, 26 per cent. good, and 9 per cent. satisfactory results. It must also be noted that under this "moveable" method not one case was complicated by aseptic necrosis of the femoral head.

*Studies on Occurrence of Experimental Purulent Osteomyelitis.* DR. K. TSUGE [167] and DR. S. TOMOCHIKA [168] reported their investigations in this field.

It is known that purulent osteomyelitis usually occurs at metaphyses and its cause is usually a thrombus in a small artery or anchoring of bacteria in a vein. The authors had tried to study the mechanism in the following experiments. First, India ink was injected into the femur of young rabbits through the nutrient arteries. The ink particles remained for a long time in the sinusoid in the medulla and its reticular system; soon, however, it became scarce in the veins of the diaphysis. When a little more was injected in the form of coarse-grained lycopodium, it was found aggregated in the vicinity of the medullary processes of the metaphyses, and it was very scarce in the portions adjacent to the epiphyseal cartilages and in the diaphyses. These particles were apparent in the sinusoids or the reticular system, but never in the venules.

When 0.02 cubic centimeters per kilogram of suspension of one loopful of *Staphylococcus aureus* culture in 2.0 cubic centimeters of physiological saline is similarly injected, in three to four days after the onset of osteomyelitis, a part of the metaphyses adjoining the epiphyseal plate shows wedge-shaped necrosis with the apex toward the diaphysis in the medullary recesses, and focal leukocytic infiltration and abscess formation were also seen in the diaphyseal side in the medullary recesses. From this, it may be concluded that there are many cases in which comparatively large masses of bacteria anchor and stay in the sinusoid or its reticular system at some distance from the epiphyseal plate by a positional difference in speed of intramedullary blood flow or in phagocytic function.

*The Healing of the Injured Epiphyseal Plate.* DR. S. KOSUGE [169], DR. S. FUJINO [170], DR. H. KIKUCHI [171], and DR. I. YOSHIDA [172] presented their observations in this field. It is not yet decided how the growth of bones is affected by injuries to the epiphyseal plates. The authors, therefore, had observed the processes of repair following local injury in the central part of the cartilaginous plate of the lower end of the femur and upper end of the tibia of young rabbits.

The results showed that if the growth cartilage was injured, cartilage cells did not reappear, but healing occurred through the formation of bone. No marked influence was observed on the longitudinal growth of the bone by central injuries.

*Angiographic Study of Fracture Healing.* DR. S. HAMADA [173] and DR. H. KOMIYA [174] presented their angiographic observations made in a study of the influences of intramedullary fixation with Kirschner wire and of encircling silk thread on the healing of fractures. They had used the India-ink infusion method in the presence of radial-shaft fractures in rabbits.

Angiographically, the repair under intramedullary fixation had been found to be delayed in comparison with the controls up to the fifth week, the rate of formation of new medullary blood vessels being lowered. They had noted that the newly formed vessels gradually approached the ends of the fragments but the intermediate callus was limited up to that time, while in some cases the external callus had resulted in union.

In the seventh week, one week after the removal of the wire, the blood vessels in the external callus had developed almost to normal, and the intramedullary blood vessels in the two fragments had become connected and open to blood flow, also showing nearly normal appearance. The intermediate and the internal callus had completely formed.

When the fragments were encircled with silk thread, newly formed blood vessels were numerous around the threads; their diameter was rather large down to the fifth week, and the connection between the vessels on both sides of the fracture was observed to be hindered by the silk threads. In the sixth week, the number of the blood vessels decreased, but many thick blood vessels still remained around the threads and the external callus persisted in the form of spongy callus full of gaps. In the eighth week the healing could not be called complete.

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[167] Okayama, Japan.
[168] Okayama, Japan.
[169] Nagoya, Japan.
[170] Nagoya, Japan.
[171] Nagoya, Japan.
[172] Nagoya, Japan.
[173] Yokohama, Japan.
[174] Yokohama, Japan.

Thus, the intramedullary fixation is an excellent method for treating fractures, but the method of encircling for fixation of the fracture is apt to cause delay of healing.

*A Clinical Experiment on the Sensitivity of Blood Vessels of the Lower Extremities.* DR. H. MATSUO [175], DR. S. INOMATA [176], and DR. K. KOSEKI [177] reported the following clinical observations relating to the sensitivity of blood vessels in the lower extremities.

1. Tensional pain of the lower limbs in the unnarcotized state may be of complex origin but it speedily disappears under the influence of high lumbar anaesthesia.
2. The excruciating pain felt on intra-arterial injection into the femoral artery also disappears similarly, but not completely until the anaesthesia reaches the level of the nipples, suggesting the existence of fibers running along the vascular walls as an afferent route directly into the thoracic spinal cord.
3. After excision of the lumbar sympathetic ganglia, vascular pain is alleviated, suggesting the existence of fibers running through the sympathetic trunk.
4. Histologically, the authors have succeeded in proving the existence of ascending sensory fibers in the sympathetic trunk of the dog.

Thus, the afferent routes for vascular sensation from the lower extremities run up for the most part as far as the lower thoracic segments of the spinal cord, but a part seems to run farther up to the higher thoracic segments through the sympathetic trunk.

*Saccharo-Protein in Joint Fluid and Articular Cartilage.* DR. H. MATSUNAGA [178], DR. M. IOKI [179], and DR. T. AOKI [180] pointed out that the viscosity of synovial fluid is almost entirely unrelated to its protein content, but is proportional to the concentration of hyaluronic acid. They had measured the specific viscosity by Ostwald's method and the content of hyaluronic acid by Disch's method and estimated the polymerization rate of synovial fluid from the ratio between the two in the following experiments.

In normal joints, the polymerization rate had been found to stand between 10.9 and 9.4 showing a rather good constancy. In osteo-arthritis it had been found to fall to 9.3 to 7.7, and in rheumatoid arthritis the ratio was also small. In particular, in tuberculous arthritis, the ratio fell very low, seemingly indicating the effect of various enzymatic changes accompanying the inflammation to which the hyaluronic acid content is subject.

The authors had measured the glucuronide values of a part of the articular cartilages by Youngberg's method and had followed up the change of metachromasia by means of toluidine-blue at pH 1, using tissue of adjacent non-cartilaginous parts.

In cases of tuberculous arthritis the glucuronide values were low and almost no metachromasia was observed. In such cases, the cartilages and their metachromasia were felt to be better conserved than in purulent arthritis, but the authors found that in the vicinity of tuberculous foci, the metachromasia was always negative and the glucuronide value was low. Indeed, the latter was found in some cases to be surprisingly low even in positions rather far from the foci, so that the authors failed to find anything to support the opinions of Sylvén and others.

*On the Internal Pressure of Joints.* DR. S. URAYAMA [181] reported his investigations in this field. He had taken the knee joints of living normal adults for his test, punctured them with needles connected to open U-tubes containing mercury, made successive injections of 5.0 cubic centimeters of physiological saline, measured the mercury column after each injection, and plotted the height on graphs. With normal joints (twenty-seven cases), the plotted points formed curves approximately parabolic, but the values of the internal pressure showed considerable variation. In osteo-arthritis (forty-two cases), some showed steeper curves than the normal, indicating reduced extensibility of the articular capsule, and some cases with large quantities of exudate showed very slowly rising curves, indicating relaxation of the joint capsule induced by long-continued stagnation of exudate within the joint.

In cases of traumatic injury of the articular cartilage (eight cases) the curves were mostly not much different from normal cases, and the same was true in the cases with intra-articular fractures (four cases). In the cases with typical fracture of the patella (seven cases), however, the curves were steeper, indicating disturbance in the joint capsule.

The curves of cases of tuberculous arthritis (seven cases) and syphilitic arthritis (one case) varied from case to case and showed no definitely characteristic pattern. These seemed to be much influenced by the stage of the disease.

The rheumatoid cases (fifteen cases) showed steep curves, indicating marked restriction of the extensibility of the joint capsule at rather early stages.

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[175] Fukushima, Japan.

[176] Fukushima, Japan.

[177] Fukushima, Japan.

[178] Tokyo, Japan.

[179] Tokyo, Japan.

[180] Tokyo, Japan.

[181] Tokyo, Japan.

When contracture of the joint is present, the curve is naturally more steep, but when traction treatment is continuously applied, the curves slope more gently. The steepness of the curve is not related to the degree of contracture, but in the same subject, it is observed to become less steep with the alleviation of the contracture.

In cases with paralyzed limbs (twenty-four cases), the curves are generally sloped very gently and the values for which the points on them stand are very low, but not uncommonly the curves become suddenly steeper in the latter half, seemingly indicating the relaxed tension but the reduced extensibility of the joint capsule. In the oldest cases, the curves rise steeply from the outset, showing that the articular cavity itself has been narrowed down.

This method may be very convenient for estimating the status of joint capsules.

### Symposium on Anaesthesia in Children

A. *Study of General Anaesthesia with Ether in Infants.* Dr. T. Tamai [182] presented his findings during experimental and clinical studies of the problems involved in the use of ether. Despite the recent progress of anaesthesiology, many difficulties have been encountered in the administration of a general anaesthetic in infants.

The concentration of ether in the blood increased with the depth of anaesthesia; for a given depth of anaesthesia, the concentration had to be higher, the greater the body weight of the patient. Concentrations necessary for the various stages of anaesthesia, as tested on rabbits, were lower in subjects of lighter body weight. Subjects with marked deviation from the normal in body weight had a tendency to attain deep anaesthesia at low concentrations of ether in the blood, but apparently not so much as to be significant. In cases with anoxia, whether anoxic or anaemic, deep anaesthesia was induced at low ether concentration, especially in small infants.

The ether concentration in the brain is higher in subjects of lower body weight, contrary to that in blood.

The author had studied the relation of the depth of anaesthesia to the respiratory movement in infants and young rabbits, based on the apparent respiratory movement and based on the use of electromyography and on the respiration curve derived from the trachea.

With respect to the relation between the depth of anaesthesia and the reflexes, it had been found that the ether concentration in the blood was lower at the point at which the reflexes reappear in regaining consciousness than that at the point at which the reflexes disappear during induction of anaesthesia.

The variation of the respirations per minute and the oxygen consumption was greater, the younger the subject.

Histological examination showed that the changes in the respiratory organs differed little between young and mature rabbits.

The changes in the blood in infants were as follows: (1) The blood findings had indicated that the number of erythrocytes had increased in fifteen of twenty cases and the number of leukocytes in nineteen of twenty cases. (2) The erythrocyte sedimentation rate was higher in eight of ten cases. (3) Dehydration was observable in many of the cases. (4) In regard to the acid-base balance, the younger the subject, the readier the appearance of decompensatory acidosis, apparently resulting from both metabolic and respiratory causes.

The most outstanding of the changes in the electrocardiogram was the picture of injury to the myocardium due to anoxia. If precautions are taken against the occurrence of anoxia or if the anoxia is dispelled after the appearance of the change, this change in the electrocardiogram disappears.

Liver-function tests showed that in general the dysfunction was slight and transient, but that in very young subjects, in subjects subjected to prolonged anaesthesia, and in cases of bone and joint tuberculosis, cases of rickets, and cases of osteomyelitis, the lowered function was more severe and lasting.

The change in body temperature was also wider in younger subjects. The temperature rose when bone and periosteum were operated upon, but when local preliminary anaesthesia was given, the rise in temperature was prevented.

Conclusions: Infants are apt to show wider changes under ether anaesthesia, calling for thorough and unfailing attention to their physiology and general condition during anaesthesia, but with such attention and with understanding of the danger symptoms the risk should be kept to a minimum.

B. *General Anaesthesia in Infants and Children.* Dr. K. Fujimoto [183] presented a method of producing general anaesthesia which he felt was more comfortable and safer for infants and children than those hitherto in use. He had combined rectal anaesthesia with barbiturates; induction had been with nitrous oxide and maintenance had been with the same or with ether (administered by the closed method with a mask in orthopaedic operations including manipulations) in small children. He had investigated the pathophysiological changes induced by the use of such anaesthesia using animals and clinical subjects as material. The results were as follows:

From the measurements of the dead space and the respiratory resistance of the anaesthetic apparatus and the tidal volume and the minute volume of infants in both normal and anaesthetized conditions, from the type of the respiratory curves, and from the electromyographic examination of the respiratory muscles, it had been concluded that smooth anaesthesia generally cannot be induced in infants under four to five years of age by closed methods (by any system). The main trouble lay in the large dead space and the respiratory resistance of the apparatus. Respiratory acidosis and slight anoxic anoxia were observed to occur under such a method. When the subject was six to seven years or older, however, such disturbances were not encountered.

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[182] Niigata, Japan.

[183] Sendai, Japan.

As for the influence on the circulatory system as checked by electrocardiograms, nitrous oxide did not produce any detrimental effect, while ether caused slight damage to the myocardium, but only to an immediately recoverable extent.

The liver function had been tested by various methods. Anaesthesia alone caused some transient disturbance of function in a few cases, but the general conclusion from the results of the tests was that the operative intervention played the more important role.

Since the ordinary anaesthetic apparatuses are inadequate for use in infants and small children, the author had devised new equipment for such use and had been enabled by it to produce anaesthesia in infants more conveniently.

C. *Application of Intramuscular Anaesthesia to Infants and Children.* Dr. H. Katsuya[184] and Dr. T. Eguchi[185] presented a method of anaesthetizing infants which they had used successfully in 226 cases.

The method consists in giving a 2.5 per cent. or 3.3 per cent. solution of hexobarbital sodium in physiological saline by intramuscular injection in several doses.

In order to study the actions at the site of injection, 0.04 grams per kilogram of body weight of 3.3 per cent. hexobarbital sodium solution was injected in the femoral muscles of dogs and rabbits. The injected site was excised in six hours to four weeks and examined histologically. Congestion, slight bleeding, cellular infiltration, and fibrin formation were observed, but such changes soon disappeared becoming scarcely noticeable in three weeks.

The minute effects of such injections on connective tissue had been studied by injection under the skin wherein the changes may be more readily demonstrated than in the muscles. In these tests results similar to those in muscle had been observed, no scar tissue or necrosis being apparent, indicating that hexobarbital sodium solutions in concentrations lower than 3.3 per cent. do not injure the tissues.

Various tests were undertaken by the authors, including electromyograms and electro-encephalograms before and after the anaesthesia. It was demonstrated that the effects of this method of narcosis were extremely slight.

Practical application: for infants less than three to four years of age a 2.5 per cent. solution and for older children, a 3.3 per cent. solution of hexobarbital sodium in physiological saline had been used. The standard dose is 0.04 gram per kilogram of body weight, injected intramuscularly in three portions at precisely five-minute intervals. The second and the third injections should be adjusted in quantity to the reaction of the subject and when necessary they have been suspended.

When induction had been accomplished as shown by contracted pupils, relaxed muscles of the limbs, and little pain sensation remaining in the skin, non-operative manipulation can be effected forthwith, but if operation is required, 0.5 per cent. procaine was recommended, given as local or spinal anaesthesia. This had been sufficient for an operation of about thirty minutes, but if the operation had required it, an additional injection of 2.5 per cent. hexobarbital sodium had been given to prevent the lowering of hexobarbital sodium content in the blood. By repetition of such additional injections, the anaesthesia may be made to last for more than two hours.

A sleep of from thirty minutes at the shortest to three to four hours at the longest had followed the anaesthesia by this method, but this sleep had been rather desirable as a counter-measure against the postoperative pain. Sometimes, excitation had appeared during waking, but this had been quieted without fail by an injection of an opiate.

If the above-described mode of application has been strictly followed, there is no ground for fear of any side-effect or postoperative complication. After the operation, adequate and appropriate transfusion and liver-protecting measures should not be neglected.

D. *Effect of Various Anaesthetics on Muscle Tone.* Dr. N. Morizaki[186] and Dr. S. Gomi[187] presented the results of their investigations in this field.

They had used electromyograms and also the internal pressure meter of Beiglböck and Junk for measuring muscle tonus. Curves of muscle extensibility were plotted experimentally by kymography and serial roentgenograms were made of experimental fractures under traction to compare with the data obtained by the above methods. The results were as follows:

The meter to measure internal pressure of muscles gave approximate quantitative indication of muscle tonus, but other external factors were apt to enter the results.

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[184] Kumamoto, Japan.

[185] Kumamoto, Japan.

[186] Morioka, Japan.

[187] Morioka, Japan.

It had been found by the use of electromyograms that stretch reflexes and spontaneous discharges appear at times of pain, an observation that may be of value in selecting the method of producing anaesthesia.

From data obtained simultaneously by the use of electromyography and internal pressure measurements at the time of voluntary muscle contraction, it had been apparent that there exists a parallelism in these methods.

The curves of muscle extensibility and the results of x-ray examinations during traction applied in the presence of experimental fractures show no parallelism with internal muscular pressure. It cannot be said that the lower the pressure within the muscle, the greater the muscle extensibility and the greater the effect of the traction. From the curves of muscle extension and x-ray observations of traction in fracture cases, it may be deduced that spinal anaesthesia is the most effective, and intravenous anaesthesia with barbiturates the least effective. When the procedure is painless, muscle extension and the effect of traction may be expected to be considerable.

Succinylcholin chloride cannot be said to be an excellent muscle relaxant, from the standpoint of orthopaedic surgery.

In short, before discussing what method of anaesthesia is advantageous in the field of orthopaedics for relaxing muscle tone and to assure good effect in reduction and traction treatments, it is important to make every effort toward painless treatment. One must be cautious about relying merely upon muscle relaxants for bringing down muscle tone.

## Symposium on Chronic Arthritis

*The Classification and Differential Diagnosis of Chronic Arthritis.* Dr. T. Kodama[188] reported upon his studies conducted at Tokyo University under Prof. Miki.

A rheumatism clinic had been established in Tokyo University, Orthopaedic Laboratory, in 1949. Of the 758 patients who had visited the clinic from then until February 1953, 656 patients whose chief symptoms were localized in the knee joints had been chosen for study.

Regarding classification and nomenclature, the author had published a theoretical system of classification and nomenclature distinct from those customarily adopted in other countries. First, he had classified arthritis by the number of the affected joints (mono- or poly-), second, by the presence of inflammation of the affected joint and, third, by the presence of systemic manifestations. The following are descriptions of the progress of the roentgenograms and of the histological findings. For example, polyarthritis systemica chronica histo-rheumatica corresponds to the rheumatoid arthritis of the usual classification, and monoarthrosis non-systemica chronica senilis roentgeno-deformans is identical with osteo-arthritis. The author emphasized that by this method tuberculosis is further subdivided by indicating the means of diagnosis, thus: histo-tuberculosa, clinico-tuberculosa, roentgeno-tuberculosa, bacterio-tuberculosa. Thus, the names of clinico-tuberculosa, histo-rheumatica, clinico-rheumatica, histo-tuberculosa, as well as others, are derived.

Regarding histology, the histological picture of the synovial membrane of the knee joint was studied in 259 cases. Punch biopsy had been performed with the aid of Takagi's arthroscope or in a manner similar to Polley's method at the Mayo Clinic. The changes noted were classified as follows: rheumatoid (R), tuberculosis (T), synovitis simplex (S), fibrosis (F), miscellaneous (M), and normal (N). Intermediate types were grouped as: Rt, Rs, Rf, Tr, Ts, Tf, and so forth, and so recorded. The relation between the clinical and the histological picture was found to be as follows: while more than half of the sixty cases of polyarthritis systemica were histo-rheumatica, the histological figures of eighty-six cases of osteo-arthritis showed R in nine cases, T in one, S in fourteen, F in twelve, M in two, N in eight, and intermediate types in the others. In conclusion, it was made clear that clinico-deformans can be induced by many different causes.

With regard to specific gravity of joint fluid: the copper sulphate reagent employed in measuring the specific gravity of blood was used after the method of Prof. Morizaki. When the specific gravity of the joint fluid exceeds 1,019, active pathological change in the synovial membrane may be assumed histologically, but whether the cause is tuberculous or rheumatoid cannot be determined by this means alone. The number and the type of the cells in the joint fluid is generally in close relation to its specific gravity.

Bacteriologically, in three of the seventy-five cases of polyarthritis systemica, the test for *Staphylococcus aureus hemolyticus* showed positive results.

Histological study of small arteries revealed that changes in the intima of small arteries cannot be used to differentiate tuberculosis from rheumatoid arthritis. The pathological changes in the media are more important.

The author also reported on the results of the erythrocyte sedimentation rate, serum protein fractions, and Rose's sheep-cell agglutination tests and their correlation.

*Sero-Immunological Study of Rheumatoid Arthritis.* Dr. K. Shichikawa[189] presented his observations in this field.

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[188] Okayama, Japan.

[189] Osaka, Japan.

He had found that marked variations from the normal are to be observed in the serum protein in rheumatoid arthritis and from the findings in other joint diseases. The various protein reactions, the erythrocyte sedimentation rate, the serum viscosity, the protein fractions, the glycoproteins, and the lipids also show anomalies, which, when marked, place the characteristics of this disease, as a systemic disturbance, in the category of dysproteinaemia.

Such abnormal serum protein causes exudation of serum into the tissues, through increased capillary permeability. The author had succeeded in gaining an insight into this mechanism by examining the Rumpel-Leed phenomenon, fibrinolysis, and also by applying cantharis vesicant as well as examining the proteins and other substances in the joint fluid. The supposition that quantitative changes in the serum proteins accompany qualitative changes, leading to the formation of heterogenous proteins in the tissues which become sources of antigen-antibody reactions had, he felt, been fortified by the findings with respect to the cellular composition of the vesical fluid and to the formation of plasma cells in the subvesical tissue as well as by the fact that kaolin mucilage sensitized with the vesical fluid is strongly coagulated by the serum of the same patient. On the other hand, the exudation of blood proteins, he felt, induces their quantitative and qualitative alteration and hastens dysproteinaemia. This condition is made more apparent by the series of serum colloid reactions (the reactions of serum lability), and the author had assumed that this serum lability probably causes the quantitative and qualitative changes of the complements accompanying the increase of globulin fractions. He had further assumed that these reactions lead to reactions similar to the antigen-antibody reaction observed in rheumatism. Thus, in rheumatoid arthritis, the complements are observed to augment in all their components the essential factor in the sensitized sheep blood-cell agglutination reaction called the Waaler-Rose test. The agglutination-activating factor contained in the fraction of serum, has many characteristics in common with the first component of the complement. This agglutination-activating factor has also been shown to be related to the agglutination reaction of kaolin sensitized with vesical fluid and with the A group of the streptococcus agglutination reaction. He felt the agglutination-activating factor, called also the rheumatoid factor, specifically becomes apparent in cases of rheumatoid arthritis, probably because of the specificity of the rheumatoid changes in the blood proteins.

He postulated that in serologically diagnosing rheumatoid arthritis, the high value of the agglutination reaction against *Streptococcus group A*, in spite of negative results in all anti-enzyme tests, can be utilized in differentiating the condition from rheumatic fever. The Waaler-Rose test shows a high rate of positive reactions only in rheumatoid arthritis (83 per cent.), a low rate (10 per cent.) in other diseases, and an extremely low rate in normal subjects. In conducting the test, the use of bovine blood cells assures better results.

*Results Following Reconstruction and Cup Arthroplasty of the Hip Joint.* DR. G. SHIMIZU[190] reported his experience with these operations. The operations had been performed on 155 hip joints of 145 patients since 1950.

TABLE I

| *Condition* | *No. of Patients* | *No. of Hip Joints* |
|---|---|---|
| Congenital dislocation in later stage | 39 | 43 |
| Old pathological dislocation | 15 | 15 |
| Old traumatic dislocation | 4 | 4 |
| Old fracture of neck of femur | 22 | 22 |
| Bony ankylosis | 34 | 36 |
| Osteo-arthritis | 31 | 35 |

TABLE II

| *Type* | *Number of Joints* |
|---|---|
| Vitallium cups | 7 |
| Acrylic resin cups | 43 |
| Polyvinyl alcohol films | 19 |
| Chrome-hardened fasciae | 4 |
| No interposition | 82 |

As for the technique, the femoral heads were sometimes used, and in other cases where the femoral heads were unfit for use, the greater trochanter was transposed into the acetabulum to replace the head. In the former cases, the operation was chiefly carried out through the anterior approach according to Smith-Petersen and in the latter cases, the anterolateral approach was used, the gluteal muscles being cut at their attachment to the greater trochanter and the joint then being opened. In forming the new joint surface an electrically driven reamer was used. When reduction of an old dislocation of the joint failed, secondary reduction was resorted to with success.

The results obtained in these cases included the following:

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[190] Osaka, Japan.

The use of acrylic resin cups was accompanied by abnormal new-bone formation but in a lesser degree than when the Vitallium cup had been used.

In animal experiments, the comparative merits of acrylic resin cups and polyvinyl alcohol films had not been easily determined, but in actual use the latter had proven fragile, somewhat more irritating than the former, had hampered absorption in the new joint, and sometimes had resulted in less stability of the limbs, as determined by electromyography.

In hip-joint reconstruction, especially when prolonged after-treatment is required, the use of a non-absorbable cup is imperative. It may be a good method to remove the cup within four to six months, when the repair of the reconstructed joint is nearly completed, regardless of whether a postoperative disturbance has been observed or not.

As far as the hip joint is concerned, in the cases where the factor of mobility may be of minimal importance, treatment without interposition is not to be condemned; this may suggest much in the future treatment of the hip joint.

The composition of interposed materials naturally influences those changes in the bones and the surrounding soft tissues which may cause postoperative difficulties, but the effect of operative technique, of the care and skill used in after-treatment, and of individual differences in patients are not to be minimized.

Following reduction after marked displacement, care must be taken to forestall paralysis, secondary limitation of mobility, fractures, and other complications, by adopting two-stage operative methods and by avoiding force.

The authors have not yet encountered cases of death due to the operation, infections, recurrence of infection, or breakage of resin cups.

The end results of seventy-three joints more than one year after operation were generally satisfactory, including twenty-two excellent, thirty-two good, fourteen satisfactory, and five unsatisfactory cases.

*Experience with Femoral-Head Prosthesis.* DR. I. SEKI[191] presented his results from the use of hip-joint prostheses.

The superiority of the acrylic prosthesis as compared with metallic types had been recognized from the points of view of irritability and foreign-body reaction.

The prostheses of the intramedullary and Judet types had revealed an excellent tolerance in the physical and dynamic examination. Tissue non-irritability in the acrylic prosthesis was proved by histo-pathological examinations.

Improved instruments for use in special techniques in performing the operation were demonstrated. He had used a modification of the posterolateral approach. He recommended complete excision of the articular capsule as a result of correlating the amount of articular capsule left after operation with pain.

Plaster fixation of one to two weeks' duration is most suitable and traction is not particularly necessary. Statistically, he had proved that active movements of the joint might be begun as early as possible; standing is permissible in four to five weeks and walking in five to six weeks after operation.

Forty cases included the following: There were eight cases of non-union, two of fresh fracture of the femoral neck of old persons, seven of ankylosis after chronic arthritis, three of pathological dislocation after hip-joint tuberculosis, six of old congenital dislocation of the hip joint.

As for postoperative functional recovery of the hip joint, the cases of fracture of the femoral neck were best, next best were those with ankylosis and with dislocation. He had noted especially that congenital dislocations of the hip had proved the most difficult. But improvements in the position of the extremity in shortening of the limb and in the gait were remarkable. Trendelenburg's sign had disappeared. The course of recovery of muscle power had been observed by the use of the electromyogram.

Factors concerned with postoperative functional disturbances included embedding of the prosthesis in the bone, overproduction of callus, contracture of the soft tissues, pain, and insufficient power of the gluteal muscles. However, it had seemed to be difficult to prevent an overproduction of callus in cases in which acrylic prostheses were used.

The postoperative complications encountered were as follows: one case of pneumonia, five of hematoma, one of paralysis of the sciatic nerve, four of infection, three of dislocation of the prosthesis, one of damage of the prosthesis. All of these complications occurred as a result of accidents during the early period of the author's experiences. There has been no thrombosis and no death attributable to the operation.

The author endorsed the opinion of Judet, who had set the comparatively limited indications for the operation. Every patient with fracture of the femoral neck, defect of the femoral head, or chronic arthrosis with extensive deformity is a possible candidate for the femoral-head prosthesis. Conditions following hip-joint tuberculosis are possible indications, if one may suppose that reactivation following operation can be excluded.

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[191] Tokyo, Japan.

*Artificial Articular Replacement.* **Dr. K. Hashikura** [192] and **Dr. K. Ito** [193] had applied prostheses with some success in the following cases.

In six shoulder joints in which there were fresh fractures of the humeral neck in old persons, extensively comminuted fractures of the humeral head, non-union of the humeral neck, and tuberculosis of the shoulder joint in the later stages, for a total of six cases.

In elbow joints in which there was severe traumatic arthrosis deformans, non-union of the distal end of the humerus, tuberculous joint ankylosis, and local humeral osteomyelitis, totaling nine cases.

In knee joints in which there had been local femoral and tibial osteomyelitis, ankylosis with deformity, and tuberculosis in the later stage, totaling ten cases.

In the lower limbs, firm fixation is important, but in upper limbs, mobility and stability of the joints is more important, so that great care had to be taken to prevent dislocation of the artificial joints by giving special consideration to the attachment of muscle in particular. According to the nature and the degree of the disease, either unilateral or bilateral replacement had been effected in cases of elbow-joint disease. The same had applied to diseased knee joints. In bilateral replacements, bolts of Vitallium were used as articular axes to effect hinge-jointing.

The oldest of the patients had been examined three years after the operation. The chronic cases, with muscular atrophy, contracture, or scar, naturally had shown bad functional results. The results in the shoulder joints showed four cases having 80 degrees of abduction and two cases with 35 degrees of abduction, but as abduction ranges increased, the rotatory movements had diminished at the last examination. The cases with muscle attachments to the groove of the greater tuberosity of the artificial head and to a part of the bone of the greater tuberosity where the supraspinatus is attached retained especially wide abduction.

There were five cases involving the elbow joint having flexion ranges from 55 degrees to 90 degrees and four cases with ranges from 25 degrees to 55 degrees. In comparsion with wide flexion and extension, the rotatory movement had been markedly limited.

Of all the joints treated, the knee joints had shown the greatest limitation of movement. Much has yet to be developed to make operations in these joints satisfactory, but the authors had succeeded in supplementing defects in bones and preventing shortening by their method.

It might seem too venturesome to practise joint replacement in cases of tuberculous arthritis, even in old cases. Now, however, that the advantage of cleansing the focus has been recognized and typical and atypical excision has been practised successfully under chemotherapy, hopes may be justified of curing such cases and at the same time retaining mobility to the greatest extent possible. This could be done through joint resection followed by reconstruction. In fact, the authors could not detect tuberculous bacilli in any one case after the operation, and although a sinus had formed in one case of shoulder joint tuberculosis and in one case of knee-joint tuberculosis, it was ascertained that the resection was inadequate in these cases. The elbow joint is especially amenable to the operation. Deformity as a complication seems to be inevitable to some extent in any of the joints. Sinus formation occurred in two cases. Dislocation of the artificial humeral head occurred in one case and a fracture of the stem of the prosthesis had been observed at the elbow joint with superfluous ossification. Some patients complained of severe pain at first, but gradually this symptom subsided. Three patients, however, continued to complain of slight pain.

The authors believe that these results are not entirely satisfactory, but are encouraging.

## Symposium on Arthroscopy

A. *The Development and Present Status of the Arthroscope.* **Dr. M. Watanabe** [194] reported that arthroscopy was first introduced by Dr. K. Takagi in 1918. It was also Takagi who, in 1920, invented the first arthroscope, an endoscope, designed for observations of joint cavities. In Western countries, E. Bircher (1921), P. Kreuscher (1925), H. Finkelstein and L. Mayer (1931), M. S. Burman (1931), and others have reported on arthroscopy and on arthroscopes, but the method seems not to have come into general use. In Japan, Takagi has made fundamental and systematic studies of the subject, thus leading the way to the general application of the method. Taking arthroscopic photographs was accomplished by him in 1932, and in 1936 he succeeded, with the cooperation of S. Iino, in making colored photographs and black and white motion pictures with the aid of the arthroscope. In 1938, Takagi reported "On the Arthroscope" at the Thirteenth Annual Meeting of the Japanese Orthopaedic Society. S. Iino (1933–1939) made studies in the field of arthroscopic morphology of the knee joints of the human cadaver, and M. Miki (1940) on the arthroscopic picture of canine knee joints, thereby establishing the standard of the appropriate concentration, temperature, and pressure of the saline used as a medium to be infused into the joint cavity. N. Morizaki (1943) studied the influence of various physical therapeutic agents in the arthroscopic picture. F. Koike (1943) studied the arthroscopic picture of experimental suppurative arthritis; K. Fujimoto (1943) the influence of various antiseptics infused into the joint; T. Okamura (1945) the arthroscopic picture of experimental traumatic arthritis, and M. Watanabe (1947) the arthroscopy of the joints of horses.

The first instance of clinical use of an arthroscope was that by Takagi who examined a case of tuberculous arthritis of the knee in 1920, and since then down to 1931, it was used chiefly for differentiating tuberculous arthritis from non-tuberculous hydrops. At the Annual Meeting in 1938, Takagi exhibited sixty-seven arthroscopic pictures of various joint diseases and injuries, including sixteen of tuberculous arthritis.

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[192] Tokyo, Japan.

[193] Tokyo, Japan.

[194] Tokyo, Japan.

Since then, the outstanding reports on arthroscopy were of arthroscopic studies on tuberculous arthritis by W. Kawashima (1942), on traumatic joint disorders by T. Okamura (1945), and by K. Sato (1940), on degenerative joint disease by M. Watanabe (1949), and on rheumatoid arthritis and non-specific chronic arthritis by S. Takeda (1951). It has also been known that symptoms are often alleviated by the manipulation of arthroscopy, M. S. Burman (1935) remarking on the "lavage of the knee joint, its therapeutic value in chronic, non-suppurative disease of the knee joint". M. Watanabe (1948) re-examined this mechanism which resulted in his proposal and application of the "joint-irrigation" method and the determination of its indications.

The arthroscopes now in daily clinical use in Japan are known for their solidity and safety against accidents. This type consists of forward and right-angle-viewed optic tubes three millimeters in diameter, a fore-oblique-viewed tube 3.7 millimeters in diameter, and some accessory apparatus. The procuring of the biopsy specimen is accomplished with the help of an arthroscope. The arthroscope for photographic use is 5.7 millimeters in diameter and includes a light bulb of thirty volts and one ampere with which a colored picture seventeen millimeters in diameter is obtained with a half-second exposure. Such a picture may be used as a lantern slide without further manipulation.

Concerning arthroscopic pictures, it has been pointed out that they show differences according to the optic conditions created by the observer, and the age and individuality of the patient. On the other hand, some characteristics were also established in the arthroscopic pictures of different joint diseases. Arthroscopy and punch biopsy provide important data for diagnosing the different entities in joint disease and should be used in combination with the x-ray examination. By arthroscopy, diagnostic arthrotomy can be dispensed with and even better results can be obtained. The result of blind punch biopsy is often very unsatisfactory.

B. *Clinical Arthroscopy with Emphasis on Osteo-Arthritis.* DR. M. WATANABE[195] classified joint diseases as follows:

1. Simple arthralgia, traumatic arthritis, osteo-arthritis, neuropathic joint disease.
2. Rheumatoid arthritis, rheumatic fever, atypical, subacute, and chronic arthritis.
3. Tuberculous arthritis, syphilitic arthritis, suppurative arthritis.

The author had measured the specific gravity, the specific viscosity, the protein content, the Mucin-N, the Mucoid-N, and the $\frac{\text{Mucin-N} + \text{Mucoid-N}}{\text{Total-N}} \times 100$ (percentage) of the joint fluids taken from 164 joints and the joint temperature of fifty-five of all the above classes. He, thereby, estimated the reaction of the synovial membranes and the severity of the synovitis. He plotted the curves of internal pressure of 162 joints and estimated the capacity of the joint cavities and the extensibility of the joint capsules.

As the severity of synovitis in general is greater in Class 3 than in Class 2 and greater in Class 2 than in Class 1, a rough diagnosis can be made from these tests, but not with accuracy. For accurate diagnosis of the nature of the disease, examination of other data, such as clinical symptoms, the course, the general condition, the bacteriological examination of exudates, and the histological examination of the synovial membrane, is required.

The severity and the chronicity of the disease can be estimated by arthroscopic examination which can show the extent of the hyperaemia, of the oedema, of proliferation, degeneration, and necrosis of the synovial villi, and the products of exudation in the cavities. The arthroscope is also of service in estimating the capacity of cavities and the extensibility of the capsules through filling with saline. It is also of value in detecting the pathological changes in the menisci. Punch biopsy done with the help of an arthroscope often helps in early diagnosis.

C. *Arthroscopic Study of Joint Disorders Caused by Injuries.* DR. K. SATO[196] had employed Takagi's arthroscopes in his studies of ninety-five cases of traumatic disease of knee joints, mainly occasioned by contusion and sprain but also including intra-articular simple fracture, snapping knees, and other internal derangements. He reports as follows:

The characteristic finding in the cases of traumatic disorders is the clarity and distinctness of the arthroscopic picture, which is unchanged except that there is some turbidity owing to hemorrhage.

In cases of simple slight contusion, only transient hyperaemia and oedema are noted in the synovial membrane, and this disappears in one to several days.

When the trauma has been severe and ruptures and hemorrhage of the synovial membrane, as well as hemarthrosis, are observed, a subacute simple inflammation persists for one to three months, and proliferation of villi is initiated in proportion to the activity of the synovial membrane. Clinically, repeated effusions into the joint cavity, pain on motion, disturbed ability to walk, and slight contracture are observed throughout.

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[195] Tokyo, Japan.

[196] Fukushima, Japan.

If, in a case with injured ligaments and severely injured synovial membrane caused by a sprain little attention is paid to the necessity of rest and the appropriate therapy in the early stages, such as restricted activities, the traumatic inflammation becomes chronic within three months. The articular capsule and the synovial membrane become hypertrophied and fibrous. The synovial villi become elongated and thickened, and the arborescent villi increase markedly. Clinical signs become chronic and fixed, and improvement is hard to induce. Thus, the disappearance of traumatic inflammation and the repair of injured tissues should be first effected by evacuation of fluids by puncture, articular irrigation, splinting, and other means, so that adequate rest and relative immobility are assured in the early stages.

As the severity of intra-articular changes caused by injury can be accurately estimated by use of an arthroscope, the plan of treatment and the prognosis can be accurately established. Often enough, pain and swelling of the joints and limitation of movement resulting from trauma are early symptoms of an articular disease, such as tuberculosis, rheumatoid arthritis, or syphilis; an arthroscopic examination is of service in such a case in facilitating early differential diagnosis.

Irrigation of the joint cavity and repeated changing of the inner pressure and temperature through arthroscopic examination have the effect of promoting healing by eliminating venous congestion, improving circulation, and activating the cells. Thus arthroscopy is effective not only as a diagnostic but also as a therapeutic procedure.

D. *Arthroscopic Views of Tuberculous Arthritis.* DR. W. KAWASHIMA [197] pointed out that arthroscopy, especially with a Takagi arthroscope, is one of the most dependable means of establishing the early diagnosis of tuberculous arthritis. In the use of the Takagi arthroscope, biopsy of the affected part is done accurately and diagnosis is possible at the earliest period when the changes are still localized to a part of the synovial membrane and before any marked change is observable clinically or roentgenographically. In such an early stage of disease, tuberculous change is circumscribed, the other parts of the joint showing only non-specific inflammation.

The arthroscopic picture of early tuberculous arthritis, proved histologically, is as follows:

Swelling and reddening of the synovial membrane is, at first, slight. Blood vessels still visible are normal in luster, but later, the oedematous swelling becomes marked, reddening is conspicuous, the blood vessels become invisible, and the surface is covered with a white exudate. Necrotic villi are found in the vicinity. In some cases, the surface is light violet-pink and "white-furred".

The following are anomalies of blood vessels: Locally the blood vessels run reticular or dendritic courses or a stellate vascular figure appears. The proliferation of villi is bacillar, hemispherical, or lumpy, and there are membranous swelling and necrotic areas of whiteness on the surfaces or at the tips. Tuberculous nodes may be seen; granulation tissue may be seen, the surface of which may or may not be covered with whitish exudate. Ulceration may be noted. Pieces of necrotic tissue may appear.

Among the types of tuberculous arthritis, the hydropic form shows some of the above changes. In some cases, even within one month after onset, the joint cavity is filled with pieces of necrotic tissue. In cases of this type, the joint fluid is usually turbid, the arthroscopic figure not being clear even at the earliest stage.

In almost all the cases of the granulation and suppurative types, the joint cavity is filled with necrotic pieces and lumps, the interspaces being filled up with granulation tissue.

In cases where the roentgenogram showed no evidence of bone destruction, destruction of cartilage was observed. In some cases in which destruction of bone was seen in roentgenograms only granulation tissue and necrotic pieces were found on the surface; underlying destruction was not visible. When bone destruction occurs near the joint, arthroscopy shows whether tuberculous changes are present in the joints or not.

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[197] Tokyo, Japan.

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## OHIO ORTHOPAEDIC SOCIETY

AS REPORTED BY FRANK E. KUGLER, M.D., *Secretary-Treasurer*, CINCINNATI, OHIO

The Annual Meeting of the Ohio Orthopaedic Society was held on May 20 and 21, 1955, under the presidency of Dr. Herbert Brumbaugh, at the Children's Hospital and the Starling-Loving Hall of the Ohio State University Medical School, Columbus, Ohio. During the scientific session the following papers were presented:

Selective Antibiotic Therapy by Dr. Warren Wheeler;
Changes in Concept After Ten Years' Experience in Franklin County Cerebral Palsy Center by Dr. Paul Miller;
Case Report: Congenital Dislocation of Hip; Shelf Operation by Dr. H. P. Worstell and Dr. Leonard Yurko;
End Results of Stapling Operations by Dr. Clyde Dawson and Dr. John Elliott;
Toxic Synovitis of the Hip by Dr. Paul Miller and Dr. Robert Larrick;
Anterior Tibial Transplants by Dr. D. D. Kackley and Dr. Leonard Yurko;
Case Reports: Hip-Joint Reconstruction in Adolescence; Femoral-Head Prosthesis; Cup Arthroplasty; and Arthrodesis by Dr. Henry Lacey and Dr. Robert Larrick;
Rehabilitation in Ohio: Organization and Proposed Program by Dr. Ralph Worden;
Inter-Body Vertebral Fusion: Progress and Statistical Report by Dr. B. R. Wiltberger;
Experimental Osteopetrosis by Dr. Hans Schlumberger;
Selective Resection of Benign Giant-Cell Tumor by Dr. William S. Smith;
Electrophoretic Patterns in the Myeloma Series by Dr. Robert Wahl;
Current Concepts in Management of Bone Decalcification by Dr. Robert H. Schoene;
Pain Mechanisms by Dr. William Hunt;
Acromioclavicular Separation: A Method of Repair by Dr. Willis T. Kubiac;
Experimental Scoliosis by Dr. F. C. Beattie.

At the close of the scientific session a business meeting was held at which time the following officers were elected for the ensuing year:

*President:* W. McGaw, M.D., Cleveland, Ohio;
*President-Elect:* H. P. Worstell, M.D., Columbus, Ohio;
*Secretary-Treasurer:* George Phalen, M.D., Cleveland, Ohio.

The 1956 meeting will be held in Youngstown, Ohio, during the month of April.

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## BOSTON ORTHOPEDIC CLUB MEETING

October 18, 1955

The first meeting of the Boston Orthopedic Club for the current year was held on Tuesday, October 18, 1955, at the Boston Medical Library. Sir Harry Platt was the speaker of the evening; his subject was Congenital Dislocation of the Hip.

Over a period of forty-one years of experience with this condition, there had been 730 dislocated hips in 577 patients. Of these 132 joints had been opened, 122 with operative notes sufficiently detailed so that they could be studied from the viewpoint of anatomical findings. In all age groups the ligamentum teres was found to be long and thick. After reduction, it is believed to form a wad of sufficient size to hinder adequate seating and congruity of the joint. Another frequent finding was that of a relatively large head which again was seated poorly in the undersized acetabulum. Occasionally too, the capsule was found to have a higher attachment on the neck than was normal, a finding which was considered of more importance than that of an isthmus. The latter is thought to be not necessarily a harbinger of a difficult reduction and a poor result. The role of the limbus in preventing reduction has probably been exaggerated. It appears to loom larger in one's view if a superior approach to the hip is used instead of the classical one of Smith-Petersen.

Although we still know little about the late results of the open procedure compared with those of the closed, there are the known advantages of ease of reduction, greater stability and congruity, with no greater incidence of osteochondritic changes in the head. However, the performance of this operation is formidable and not to be undertaken by the occasional operator. It should be carried out without delay on relaxation of the hip or in the occasional case in which reduction appears to be either impossible or excessively difficult after study of the plane films and arthrograms. Although there should be more open reductions than have been done in the past, closed reductions should still be the first line of defense. Our experience with traumatic dislocations should not lead us to expect the same anatomical result to be obtained as when a normal head is replaced into a normal acetabulum. Congenital dislocation presents varying degrees of malformation with structural changes becoming worse the longer the child walks before treatment is applied. Before walking, the method of gradual reduction by abduction is best. The functional result will exceed the anatomical and may be expected to be good for a matter of twenty or twenty-five years. After that the head will wear out and become an arthroplastic problem.

*Reported by R. M. Kilfoyle, M.D.*

# News Notes

The Second Annual Meeting of the **Orthopaedic Research Society** will be held at the Palmer House, Chicago, Illinois, January 28, 1956.

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The next Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held, under the presidency of Dr. Walter P. Blount, at the Palmer House, Chicago, Illinois, January 28 to February 2, 1956.

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The next Annual Meeting of **The American Orthopaedic Association** will be held at the Banff Springs Hotel, Banff, Alberta, Canada, from June 20 to 23, 1956.

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The Eleventh Annual Meeting of the **American Society for Surgery of the Hand** will be held at the Palmer House, Chicago, Illinois, on Friday, January 27, 1956.

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## SOCIEDAD LATINO AMERICANA de ORTOPEDIA y TRAUMATOLOGIA

The *Sociedad Latino Americana de Ortopedia y Traumatologia* will hold its third meeting in Mexico City from January 16 to 21, 1956, under the Chairmanship of Dr. Alejandro Velasco Zimbron. The Latin-American Society came into being in 1946 when Dr. Juan Farill, Mexico City, called together the Latin-American orthopaedists who had attended that year's meeting of The American Academy of Orthopaedic Surgeons for the purpose of "getting our orthopaedists together in order to raise the standards of our specialty, increase our friendship, improve our knowledge, and give better service to cripples".

The first meetings of the Society were held in 1950 in Montevideo and Buenos Aires with an attendance of about 300 specialists. The second meeting was held in 1953 in Quitandinha, Brazil, and the attendance was over 600 orthopaedists and traumatologists. Because Mexico is farthest north of the Latin-American countries and because of the problems of exchange the committee doubt if this attendance will be matched at the January meeting.

The Latin-American Society has national chapters in every Latin-American country. Each chapter appoints a member of the Executive Committee of the Society. The present President of the Society is Dr. José Luis Bado, Montevideo. Dr. Juan Farill is both Honorary President of the Society and Honorary Chairman of the Mexico City meeting.

More North American orthopaedists have attended each of the meetings of the Latin-American Society. They will be welcome at Mexico City, January 16 to 21.

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## TRIBUTE TO H. WINNETT ORR

The Nebraska Orthopedic Hospital, Lincoln, Nebraska, took occasion, in its recent observance of its Fiftieth Anniversary, to pay special tribute to Dr. H. Winnett Orr, who was one of the two doctors who constituted the original staff and who, except for two years of foreign military service, has given the hospital fifty years of continuous service.

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The **New Jersey Orthopaedic Society** has announced that it will make an award annually of $100.00 in cash for the best original paper in the field of orthopaedic surgery by an intern or resident (in any field) in a New Jersey hospital. The paper may cover any aspect of the field, such as pathogenesis, pathology, diagnosis, or treatment. The work on which this paper is based must have been done during, and completed not later than six months after, internship or residency in a New Jersey Hospital. For the current award the paper should be submitted to the secretary of the Society, Dr. Arthur S. Thurm, 533 West State Street, Trenton 8, New Jersey, not later than January 15, 1956. The award will be announced in sufficient time to permit inviting the winner to present his paper personally at the Spring Meeting of the Society.

# Book Reviews

Kinesiology of the Human Body under Normal and Pathological Conditions. Arthur Steindler, M.D., (Hon.) F.R.C.S. Eng., F.A.C.S., F.I.C.S. Springfield, Illinois, Charles C. Thomas, 1955. $19.75.

How fortunate for orthopaedic surgeons that Arthur Steindler found the great energy to complete this work, for no other among us is equipped to do so. This magnificent work is the record of an arduous and lifelong study of this subject. Dr. Steindler expressed the belief that his first book on this subject, published in 1935, met with an indifferent reception. Actually, it was not an indifferent reception; rather it was a bewildered reception by a reader group incapable for the most part of fathoming the complex mathematical computations which enveloped so many of the subjects presented. In this treatise, this master teacher has come down to his readers' level of understanding and has given us a much needed treatise presented in a palatable form — indeed an exciting form.

The book is divided into a series of thirty-eight lectures. Part 1 takes up general kinetics; Part 2, the trunk including the entire spine; Part 3, the extremities; and Part 4, the gait. In orienting the subject of kinesiology, Dr. Steindler states: "Motor events are a long chain of cause and effect. Kinesiology caps this chain of events at a point just back of the clinical manifestation." The book is extremely valuable for its analysis of skeletal injuries and would have an important place in any orthopaedist's library for this phase of the subject alone. Each joint of the body is taken up individually and the kinetic findings are analyzed in terms of their clinical implications. The subject of anatomy of the musculoskeletal system becomes alive. Bones, joints, and muscles become functioning units. Physical structure becomes so much more understandable when it is interpreted in terms of function.

The kinetic findings in the paralyses are analyzed and the operative reconstructive procedures are viewed in this important light.

Kinesiology deserves a higher place both in our resident-training program and in our clinical practices. In recent years, we have given greater recognition to the importance of pathology. This book does for orthopaedic anatomy, in making it a living dynamic subject, what some have tried to do to make pathology a living dynamic subject.

While this book is written primarily for orthopaedic surgeons, physiatrists, anatomists, and physical educators, it avoids oversimplification and superficial conclusions. Dr. Steindler refuses "to somersault over the hard facts of basic sciences". It is not a book to be read lightly, but rather a book to be studied and used through the years. This is not a book that will be out-moded in a few years, but rather is in itself an entire library of the subject of kinesiology and will serve its reader through a lifetime. No physician or educator who deals with the musculoskeletal system can consider his library complete without this brilliant treatise.

*J. Vernon Luck, M.D.*

Surgery of Face, Mouth, and Jaws. Frank McDowell, M.D., James Barrett Brown, M.D., and Minot P. Fryer, M.D. St. Louis, The C. V. Mosby Co., 1954. $6.50.

This splendid monograph on *Surgery of the Face, Mouth, and Jaws* is a reprint of the chapter by the same title in Lewis-Walters' *Practice of Surgery*, 1954. It is a practical, well illustrated compendium drawn from the wide experience and many fine publications of the authors. An encyclopedia was not the intent of the authors, but rather a compact, practical, clinical guide to the reader.

The largest segment of the book (forty-nine pages), devoted to fractures and soft-tissue injuries of the face, should interest all surgeons dealing with trauma. Throughout this section simple principles are emphasized and methods utilizing standard operating-room instruments and equipment are described. There are such paragraph headings as "When to Do the Primary Repair", and "General Plan of Repair". The authors have wisely "omitted the possible use of plastic headcaps, external appliances, and complicated dental appliances . . . because these are not needed and there are more efficient means of fixation".

Also included in the monograph are sections on the clinical examination of the mouth and jaws, anaesthesia, preoperative and postoperative care, infections, disturbances of the temporomandibular joint, congenital anomalies, benign and malignant tumors, and the indications and techniques of neck dissection. The pages on congenital anomalies are very complete and include discussions of unilateral and bilateral cleft lip, cleft palate, secondary correction of these lesions, and finally anomalies of the ears, jaws, and eyelids.

The authors go on to describe the classical concept of the fusion of processes in the development of the face. They do not mention the evidence of Pohlmann, Veau, and Stark which convincingly disproves this concept. The recent evidence indicates a deficiency of mesodermal tissue spreading beneath the primitive ectodermal hood covering the mouth. With insufficient support from the underlying stroma, the ectodermal hood bursts, and a cleft results.

As a concise text of the more important lesions of the face, mouth, and jaws, the monograph is excellent. It will have special appeal to surgeons dealing with trauma, because fractures and soft-tissue injuries of the face are dealt with in a simple, direct manner, in marked contrast to the confusing and unnecessarily complicated picture often given.

*Bradford Cannon, M.D.*

Essentials of Orthopaedics, Ed. 2. Philip Wiles, M.S., F.R.C.S., F.A.C.S., London, J. & A. Churchill, Ltd.; Boston, Little, Brown and Company, 1955. $19.59.

Philip Wiles possesses, to a remarkable degree, the capacity of recognizing the vital or essential elements of a surgical subject and of expressing them simply, concisely, and lucidly. His book *Essentials of Orthopaedics* is exactly what its title implies—a presentation of the pith of orthopaedics. The work is eminently succinct and it is remarkably sufficient.

The First Edition appeared in 1949. A reprinting was necessary in 1951, and now, because of the changes that have taken place during the five years that followed the appearance of the First Edition, it has been necessary to rewrite several of the selections and revise others. As the author states in the Preface, "Every page has been corrected or revised and there is not a chapter without major alterations to several sections. Many of the old illustrations have been replaced by better examples. A few have been omitted and about thirty new figures have been added." Especially complete has been the revision of the chapter devoted to back pain. The Second Edition is longer by only fifty-one pages, an increase that is not great enough to change the outstanding quality of the work — conciseness.

As one has occasion over the years (and one often does) to refer to *Essentials of Orthopaedics* in the course of practice, teaching, and writing, the wonder grows how Mr. Wiles managed to say so much in so little space. It is really all there.

It seems a pity that one with so much talent for recognizing essentials did not include a list of references. The truths he tells so simply but so clearly have been gleaned from a wide experience and an extensive literature. The author's selection of key articles covering the field of orthopaedic surgery would have been invaluable.

This Edition is recommended for all who have any important connection with the field of orthopaedic surgery.

*William A. Rogers, M.D.*

Fractures and Joint Injuries, Vol. 2, Ed. 4. Sir Reginald Watson-Jones, B.Sc., M.Ch.Orth., F.R.C.S., F.R.A.C.S. (Hon.), F.A.C.S. (Hon.). Edinburgh, E. & S. Livingstone, Ltd.; Baltimore, The Williams and Wilkins Company, 1955. $22.50 (two volumes).

The second volume of the Fourth Edition of this world-famous classic appeared in April 1955. For several years a place has been reserved for this volume in thousands of libraries the world over. The volume comes fully up to expectations. It is in every way a masterpiece. The style is vivid, the illustrations drive home the important points in the lucid text, so that one can hardly imagine that any doubt of the author's meaning could arise. The opinions are authoritative. While the experienced fracture surgeon may not always agree with Sir Reginald—indeed, he often does not—the position has been made perfectly clear. Sound evidence has been adduced in support of the views expressed and the methods recommended are logical.

In the chapter devoted to injuries of the hip, one notes that the author has carefully weighed the many factors involved in present-day treatment and has arrived at a sound viewpoint. He recognizes a place for the prosthesis in hip surgery and by giving very little page space to the subject tacitly points out that much remains to be known in this field. One can hardly fail to applaud this attitude. In the management of leg fractures where delayed union is present the stress is on prolonged immobilization rather than operative intervention, a view with which many will not agree on economic grounds.

All that was said in the review of Volume 1, which appeared in the July 1952 issue of the American Volume of *The Journal*, is applicable to Volume 2. It is pre-eminent as a teaching book and it is of tremendous value to the surgeon who deals with fractures.

*William A. Rogers, M.D.*

Atlas of Musculoskeletal Exposures. H. F. Moseley, D.M., M.Ch., F.A.C.S., F.R.C.S.(Eng.), F.R.C.S.(C). Illustrated by Helen T. MacArthur with Five Plates by Frank Netter. London, Sir Isaac Pitman & Sons, Ltd.; Philadelphia, J. B. Lippincott Company, 1955. $22.50.

This book consists of excellent anatomical drawings which give the reader a fairly clear and complete picture of the area under discussion by the author. Dr. Moseley does not write anatomical detail in discussing exposures, but rather indicates in broad terms the route followed without verbose description. The course of approach outlined by him in the various exposures detailed is not new and covers only orthopaedic problems. However, he has included all of the important routes of exposure, without complicating his treatise by adding a list of all possibilities and without confusing the reader with rare and unusual approaches.

The sections on the face and the extremities are complete and contain all necessary modes of exposure. The accompanying drawings clarify the anatomical problems for the reader so that he may make the variations indicated for his specific problems.

Although the section on the spine and trunk is good, it is not as complete as one would desire. However, it does contain most of the standard exposures in common use by the orthopaedic surgeon.

I feel that this book is worthy of attention by the orthopaedic surgeon and will be a very useful working guide, especially to the younger men in the profession.

*E. R. Schottstaedt, M.D.*

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BASIC SURGICAL SKILLS. A Manual with Appropriate Exercises by Robert Tauber, M.D., F.A.C.S. Philadelphia, W. B. Saunders Company, 1955. $3.75.

This is a spiral-bound manual of seventy-five pages, with fifty-one diagrams. The author begins by describing an easily constructed training board on which the procedures can be practised and then, by means of large, clear diagrams and concise, move-by-move directions, he details the making of square knots, with and without instruments, with either hand; of different types of stitches, mattress, Z-type, figure-of-eight, Lembert, Halstead, twin, continuous, running, the last stitch and final square knot. He describes simple continuous sutures, sutures with locked stitches, "hemostatic", subcuticular and purse-string sutures, continuous Lembert, mattress and Cushing Sutures; running sutures with the atraumatic needle and with doubled ligature. The final section of the manual is devoted to prophylactic hemostasis.

*J. A. R.*

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THE ANATOMY OF THE HUMAN BODY. Henry Gray, F.R.S. Ed. 26. Edited by Charles May Goss, M.D. Philadelphia, Lea and Febiger, 1954. $16.00.

The familiar aspect of *Gray's Anatomy* will again be recognizable in this Edition. Few major changes in arrangement have been made. The chapter dealing with surface anatomy has been made the second chapter, where medical students will be more likely to see it before the end of their first-year course. The section describing the nose has been moved from "The Organs of the Senses" to "The Respiratory System" where it will fit into the current concept of an upper-respiratory system. The section on the heart has been given the status of an independent chapter instead of being somewhat obscured among the details on the development and histology of the vascular system.

The major revision in this Edition has been made in "The Peripheral Nervous System". This chapter has been completely rewritten in an attempt to integrate the time-honored descriptions of the older editions with the results of a large amount of research published in recent years. The sequence of presentation is much the same, but headings and subheadings have been inserted, and the numbering of paragraphs should make it easier for the student to follow the various ramifications of the nerves and to keep them in their proper relation to parent stems or branches. The parts referring to the autonomic nervous system have been greatly expanded, in order to ensure a logical and physiologically correlated presentation.

A beginning has been made in this Edition with supplying bibliographical references for the authentication of statements in the text and to provide sources for more detailed information. Former editions have had occasional footnote references, but in the sections newly revised, especially in "The Peripheral Nervous System" and "Embryology", many references to recent and classical treatises will be found.

The first chapter contains, by way of introduction, a more complete account of the various divisions of anatomy and definitions of important general terms. The account of the earlier embryology has been made more concise and is concerned more closely with human material. Many of the sections dealing with embryology and histology throughout the book have been revised. A number of new drawings of parts from cadavera, made at a magnification of five times, have been substituted for old and inadequate diagrams of microscopic anatomy.

The nomenclature has again been based upon the *BNA* except for a few instances in which the *BR* or the *INA* has afforded clear-cut improvement.

*J. A. R.*

---

THE STRUCTURE, COMPOSITION AND GROWTH OF BONE, 1930–1953. A Bibliography, Compiled by Marjorie C. Spencer and Katherine Uhler. Washington, Armed Forces Medical Library, Reference Division, Superintendent of Documents, 1955. $1.00.

The compilers have listed 2,970 books, articles, or abstracts. The general arrangement is a classification by subject following a three-page table of contents. In each classification, the entry is alphabetical by author. At the end of each classification are cross-references to entries in other classifications. There is a complete author index.

Under each entry the compilers note the number of references to the particular subject and include references to abstracts of the article or book. Wherever title is not self-explanatory, a brief description is given.

Factual description can express little appreciation of the amount of labor that has gone into the preparation of this volume. We quote from the Preface, "The bibliography serves as a powerful catalyst for accelerating and even inducing investigations that may fill the larger gaps in our knowledge and lead sooner to a comprehension of the physiology of bone."

*J. A. R.*

Introduction à la Pratique Chirurgicale de la Hanche. Recherches Anatomiques Personelles. Déductions Chirurgicales Pratiques. Jean Cheynel. Paris, G. Doin et C^ie^, 1954. 975 Fr.

Cheynel's well-written monograph is amazingly informative, considering its small size (102 pages). There are two main sections of equal length. The first considers the anatomy of the hip, particularly from the standpoints of circulation and the development of the joint. In addition to presenting the results of some of his own research on the circulation of the femoral head and neck, the author gives particular consideration to the work of Trueta and Harrison. The varying status of the circulation of the hip in the newborn, the adolescent, and the adult is discussed. The advantages and disadvantages of the different standard surgical approaches to the hip are considered, the alternative treatments of the capsule are examined with regard to the interference with the circulation to the femoral head and neck, and specific recommendations are made, these factors being taken into account.

In the third chapter of this section, Cheynel discusses the comparative anatomy of the hip in the Negro and white infant. He advances several interesting hypotheses to explain the difference in incidence of congenital dislocation of the hip in the African Negro and the European white races. He found, for example, in a study of post-mortem specimens at the School of Medicine at Dakar, that the Negro infant has less anteversion of the femoral neck and a deeper acetabulum than the European infant. "Agenesis" of the roof of the acetabulum is believed to be due to a transitory circulatory deficiency which occurs with greater frequency in the white foetus because of anatomical peculiarities of the pelvis.

In the second section, on Medical-Surgical Conclusions, treatment of congenital dislocation of the hip, degenerative arthritis of the hip, and fractures of the neck of the femur, both recent and old, are briefly taken up. The author's recommendations are conservative, and in many respects do not differ greatly from the consensus in this country. However, all-metal stem and medullary prostheses are not mentioned.

Frequent references are made throughout the monograph to the publications of the major European workers in the field, but there is no bibliography except to the author's own publications. It is unfortunate that this interesting monograph is neither sufficiently detailed nor documented to serve as a reference either on the anatomy or the surgery of the hip.

*Robert A. Knight, M.D.*, and *Ian A. Mayne, M.D.*

Operative Orthopedic Clinics. Lewis Cozen, M.D., and Alvia Brockway, M.D. In collaboration with Paul E. McMaster, M.D. Philadelphia, J. B. Lippincott Company, 1955. $10.00.

In attempting, figuratively, to bring the reader to the operating table through the medium of a book, the authors have undertaken one of the most difficult problems in surgical pedagogy. *Operative Orthopedic Clinics* is made up of a large series (226 separate cases) of surgical vignettes. Each sketch comprises a brief preliminary account of the gross operative findings, the dictated report of the operating surgeon, and, last, such remarks as he might make during and after the procedure. Although the selection of the cases has been based mainly on the variety and the teaching value of each operation, there are many gaps in the coverage of orthopaedic subjects; the consideration of fractures is quite meager. The authors point out, however, that this is not a reference work.

There is considerable information of value in *Operative Orthopedic Clinics*. Unfortunately, it is hidden by quantities of poorly written and inadequately edited material that is difficult reading. The authors state, in the preface, that each operative report has been edited "somewhat", and suggest that "Had the operative reports been dictated more carefully, a more lucid picture of the operation would be present in many instances." The reviewer readily agrees with this; in fact, it should serve as an object lesson to all surgeons. There are, as one might expect, some statements with which all orthopaedists will not be in accord.

The illustrations consist entirely of line drawings. Most of them are excellent, some are quite poor and even out of proportion, and a few add nothing to the book. The bibliography is excellent, but there are an excessive number of errors.

This volume will be of little value to the young resident. It will, on the other hand, be worth-while reading for the senior resident, who has the judgement to recognize the "pearls" when he finds them, and who still has the time to ferret them out. The practicing orthopaedist will probably not have the time required to study the book in such detail.

*Robert A. Knight, M.D.*

FOURTH ANNUAL REPORT ON STRESS. Hans Selye, M.D., Ph.D. (Prague), D.Sc. (McGill), F.R.S.(C), F.I.C.S. (Hon.) and Gunnare Heuser, M.D. (Cologne). With the Editorial Assistance of Maria Schwappch. Montreal, Acta, Inc., 1954. $10.00.

Dr. Selye, with a new co-author, has again given us an extensive guide to the literature on stress. He has also kept in this 1954 Report the somewhat unusual form of presentation used in previous reports; once this technique has been mastered, the 4,828 references become valuable source material. An especially outstanding feature of the book is the inclusion of ten special articles by guest authors, each an authority in his field. S. A. Simpson and J. F. Tait discuss the newest of the mineralo-corticoids, aldosterone; W. S. C. Copeman and O. Savage of the Rheumatism Department, West London Hospital, England, present their results of treatment with long-term cortisone (forty-five cases) and discuss their experience with ACTH administration. G. W. Harris and C. Fortier present their fundamental work on regulation of the anterior pituitary; there is a section on hypertension by A. Grollman; and F. D. Moore has been given the unusual opportunity of bringing up to date an article he published in 1952 on bodily changes in surgical convalescence. We are indebted to Dr. Selye for bringing together these articles on timely subjects which present the most recent advances in the respective areas selected.

Again, as has been stated in earlier reviews of the annual reports, this year's report is not intended to be read from cover to cover in sequential fashion; it is strictly a reference book organized in such a way as to make easily accessible such literature as may be pertinent to certain topics in the general field of adaptation to stress.

*Patricia H. Benedict, M.D.*

THE JOINTS OF THE EXTREMITIES. A Radiographic Study. Notes on Non-routine Methods, Non-routine Ideas, and Less-common Pathology. Raymond W. Lewis, M.D. Springfield, Illinois, Charles C. Thomas, 1955. $8.50.

On the title page of this book one finds: *The Joints of the Extremities, A Radiographic Study. Notes on Non-routine Methods, Non-routine Ideas, and Less-common Pathology.* These words summarize very aptly the unusual contents.

Throughout the monograph there is the constant emphasis on the importance of clinical knowledge, meticulous roentgenographic technique as well as a wide understanding of anatomy and physiology. The author over the years has learned much about unusual conditions of joints, and in these chapters discusses the best approach from the standpoint of patient comfort, type of film, and method of roentgenographic examination which may yield the greatest amount of information. It must be recognized that these results follow years of careful and detailed study, and are not likely to be attained by a technician or physician unless his interest is high and his diligence is great.

The general presentation of the material is excellent and only minor suggestions are to be made. The illustrations are of good quality and are further clarified by line drawings; however, the relationship of the illustrations to the text material is not as good as it might be. There is some duplication of illustrations of certain conditions, whereas less repetition with more emphasis on other lesions might be more informative.

This book can be used to advantage by those who are interested in the subject of joint disease, but it is unlikely that the novice will immediately attain results comparable to those of the author.

*Laurence L. Robbins, M.D.*

LES ARTHROPLASTIES DE LA HANCHE (Études critiques à propos de 200 cas opérés). Jean Debeyre et Paul Doliveux. Paris, Éditions Médicales Flammarion, 1954. Fr. 1.700.

This publication of about 90 pages represents an important contribution to the problem of hip arthroplasties. In the introduction the authors state that, since 1949, they have operated on 400 patients and have used Judet's prosthesis and the Vitallium cup.

There is an introductory anatomical review dealing concisely with pertinent facts: the architecture of involved structures, the relative thickness of constituent parts of the acetabulum, the distance of the sciatic nerve from the acetabular rim (only thirty-six millimeters), the length and inclination of the neck, the vascularization of the capsule, and the iliopsoas muscle.

A review is given of physiological principles applied to the mechanics of the hip joint, explaining the role of articular pressures, the length and inclination of the femoral neck, the articular coaptation, the action of muscles of varying leverage, and the predominance of the gluteal muscles.

The requirements for an adequate prosthesis in view of the mechanics, and various types of prostheses, as used in France, are discussed.

A short but excellent description of surgical techniques with complications and operative and postoperative difficulties is an essential part of the text. The final chapter of the book includes an excellent analysis of late postoperative results according to the various afflictions of the hip in which prosthetic operations were done.

The conclusions of the authors in brief are: There are an increasing number of failures in spite of strict adherence to theoretical requirements, even in those cases which appeared excellent in the beginning. Prosthetic arthroplasties should not be undertaken lightly and should be done in well indicated cases. The Vitallium cup can still be used profitably in selected cases.

*Les Arthroplasties de la Hanche* is a very valuable book and should be known to every surgeon who is confronted with hip-joint problems.

*Emanuel B. Kaplan, M.D.*

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"Johnny Goes to the Hospital", reviewed by *The Journal of Bone and Joint Surgery* in October, 1953, was written by Josephine Abbott Sever to help Johnny's mother and father help Johnny allay his fears and doubts about the experience ahead. This delightful little booklet, written for children who were soon to become patients at The Children's Medical Center, Boston, Massachusetts, met with phenomenal success. Thousands have been printed and distributed to all corners of the Globe.

Now appears "Johnny Visits His Doctor". Again Mrs. Sever "in words simple enough for a young child" but with deep understanding is helping "Johnny" happily along his way. The Staff of the Children's Medical Center has authenticated the text and has included a list of immunizations which every child should have and the age at which each should be given. The little booklet is attractively designed with illustrations in four full colors by Mary Stevens who illustrated "Johnny Goes to the Hospital". These reflect complete understanding of children and their reactions to their medical experiences.

The booklet is a light cheery little package, 32 pages, four colors, for ages three to eight. It may be purchased through the Department of Public Relations of the Children's Medical Center, 300 Longwood Avenue, Boston 15, Massachusetts, and the price is fifty cents.

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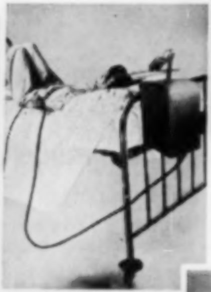

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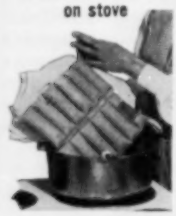

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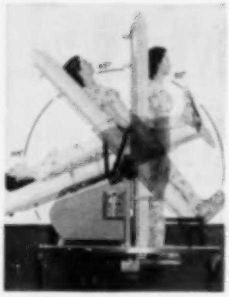

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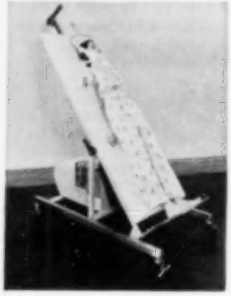

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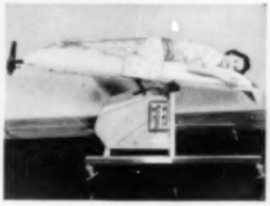

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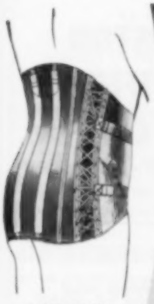

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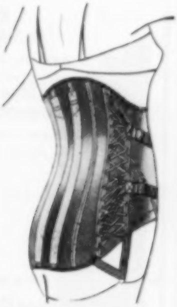

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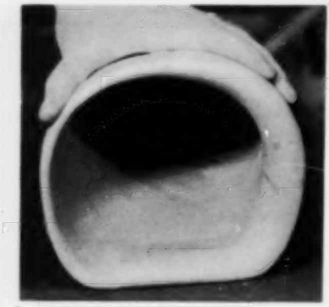

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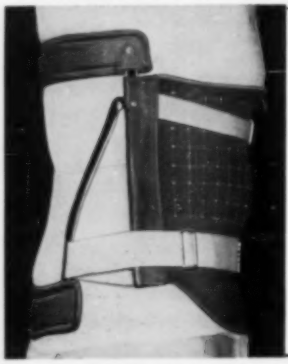

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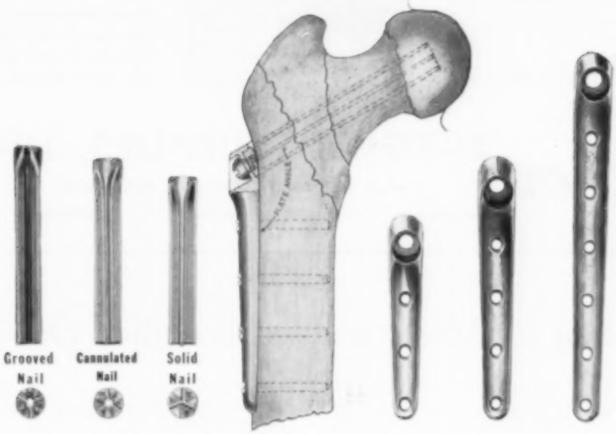

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